# **EMIGMA Modelling of TDEM Data**

## Case 1. Without Use of Imported Field Data:

#### Forward Simulation - i.e. Building your model

Of course it is always easier to open a previously-created TEM dataset and adjust the model parameters. You will find several examples in the sample databases available on the downloads page of our website(www.petroseikon.com).

• If you do not already have a project in which you wish to work, Click the **Create Project** button in the bottom left-hand section of the **Database** window. In the **Select** dialog to appear, select the **Start a New Modeling Survey** button:

Select	
C Start a new mo	delling Survey
<ul> <li>Create a blank</li> </ul>	Project
ОК	Cancel

• In the Name for New Project dialog to appear, type in the name of your project and click OK:

Name for New Project		×
Type Name for	New Project	
OK	Cancel	

The **Property Pages** window to open contains four tabs allowing you to specify your system geometry, waveform, profile information and output.

TX-RX Page:

-	Output ]	-		1.000		
ystem Name			System Type	Fixed Tx, Mo	oving Rx	
	Transmitter Coord System:	Absolute: Parallel to absolute system	×	Separation(s	) (moving system	input>
. System Mode						
EM/IP/Resistivity	-					
Fixed C Moving						
2. Transmitter Type-						
C Coll C Current Dipole						
C Loop C Pole						
Transmitter Input>	1					
	<u> </u>		- 11			
Tx/Rx Replacement Mode-	Heceiver	Undefined	T Compo	nent 0	Select All	Create Com
Tx/Rx Replacement Mode- Add C Replace	Receiver Coord System:	Undefined	Compo	nent 0	Select All	Create Comp
Tx/Rx Replacement Mode- C Add C Replace 3. Receiver Type-	Coord System:	Undefined	Compo	nent  0	Select All	Create Comp
Tx/Rx Replacement Mode- C Add C Replace 3. Receiver Type C Coil C Voltage Dipol	Coord System:	Undefined		ment 0		
Tx/Rx Replacement Mode- Add C Replace	Coord System:	Undefined		nent 0		
Tx/Rx Replacement Mode- C Add C Replace 3. Receiver Type C Coil C Voltage Dipol	Coord System:	Undefined		nent 0		
Tx/Rx Replacement Mode- Add C Replace 3. Receiver Type Col C Votage Dipol C Loop C Pole	Coord System:	Undefined		nent 0		
TwRx Replacement Mode- C Add C Replace 3. Receiver Type Coli C Votage Dipol C Loop C Pole	Coord System:	Undefined		nent 0		

This page encapsulates the capabilities of EMIGMA for a wide variety of geophysical systems. This example will illustrate one such system.

1. Transmitter Mode - select "Fixed" for fixed loop survey

2. Transmitter Type - select Loop

3. Click on "Transmitter input ->".and set the approximate loop size. And the **Add Extended Source** window appears, Loop coordinates may be edited

Set Height of Antenna to 0.01 in the following window and click OK.

ote: To	edit a value, double-cli			tertex # 5
lumber o	of Vertices 5	Center X	0.000 Y 0.000	
N	×	Y	Z	× 250
2	250.0000 -250.0000	250.0000 250.0000	0.1000 0.1000	Y 250
	-250.0000 250.0000	-250.0000 -250.0000	0.1000	Z 0.1
	250.0000	250.0000	0.1000	Insert
				Replace
onstant	Height of Antenna	0.1	Apply To All Vertices	Import Transmitter
hift Cool	rdinate 🔀 💌	0	Shift	Reverse Current
orizonta	l Rotation Angle (degre	es) 0	Rotate	Create Simple Loop
ote: Rol	tation angle is Anti-cloc is around the center of	kwise from East.		Prev Tx Next T

Note: You are not restricted to four cornered loops.

4. Receiver Type – "Dipole"

Receiver Input - Select components you wish to measure, i.e. Hx, Hy and Hz

Receiver	- Dipole		×
	Dipole Code(s) f	or each station	
	🗖 Ex	₩ Hx	
	🗖 Еу	🔽 Hy	
	🗖 Ez	₩ Hz	
	Retrieve/Re	store Data>	
[	ОК	Cancel	

#### 5. Component

Click **Select All** to create a component for each transmitter receiver combination. To specify an individual component, select a single transmitter and receiver then click **Create Comp**.

Tx-Rx						×
System Name			System Type	Fixed Tx, Moving	ı Rx	
1. System Mode EM/IP/Resistivity	Transmitter Coord.System:	Absolute: Parallel to absolute system		Separation(s) (mor	ving system) input …	>
○     Fixed     ○     Moving       2. Transmitter Type       ○     Coll     ○     Current Dpole       ○     Loop     ○     Pole       Tume x Current (Amp)     1	1. TX-ANTENN	IA LOOP Number of vertices = 5				
CARk Replacement Mode     C Add	Receiver Coord System: 1. RX:DIPOLE 2. RX:DIPOLE 3. RX:DIPOLE	Hy	verticz Compr	onent 3		ate Comp
			< Back	Next >	Cancel	Help

#### 6. Receiver Coord. System

Select "Horizontal" as the coordinate system for surface systems Select "Uhole" as the coordinate system for borehole systems

Refer to the main EMIGMA manual for details of the different coordinate systems

#### Waveform Page

81	Freq	Erecuence Total
	0.007000	Frequency C Static Frequency Total 57 C mSec
_	0.01700	Waveform: C Sec
	0.02700	© Spectral C Time Wavelount 1
	0.03700	Preview Transform Pulse To Step
	0.04700	Fieguency Mode Plase 10 Step
	0.05700	
	0.06700	Cogarithmic Step
	0.07700	Add C Replace     Initial Frequence(Hz)
	0.08700	initial requency(Hz) I' C Base 2
0	0.09700	Frequency # 57 # of Decades in 3
1	0.1070	ascending order 10 6 Base 10
2	0.117	Frequency value(Hz) 18.7 # Freq/Decade 3
3	0.117	*riet/becase 12
4.	0.1370	
5	0.1470	< Add to List < Add to the Frequency List
5	0.1570	
7	0.1670	r- Spectral Mode
8	0.1770	
9	0.1870	Cenerated
0	0.07000	
1	0.1700	Starting sequence index 1 Minimum frequency 0.007
2	0.2700	Enderson II. Holese for some 10.7
3	0.3700	End sequence index 1 Maximum frequency 18.7
4	0.4700	Number of harmonics to skip
1	0 5700	from 0 to 15 Base Frequency (Hz) 30
12	A	base riedbency (nz) [30
	Retreive/Restore	(- Generate and Add to the Frequency List Base Period (s) 1

Waveform mode - Select "Spectral", then specify a base frequency to generate a frequency list. To modify the default settings: in the **Spectral Mode** section, input a different starting sequence, end sequence and skip: e.g. 2,4,4

#### Click the Generate and add to the frequency list button.

Notes: the second frequency must be below the base frequency. Use a spectral sequence of 2 to 4 for crone surface data (base frequency of 30 Hz). Use a spectral sequence of 1-4 for borehole data (base frequency of 15 Hz). You may want to go as high as an end spectral range of 5. A skip rate of 4 is usually sufficient. Refer to your transform manual for more information on setting spectral ranges.

This step is only required once. After the first model and the transformation to time domain, all the settings are automatic.

#### **Building a Profile**

# Nar	and the second se	Survey #	19	C Modify Profile	1	
		Total number of Profiles	1990 - Carlos - Carlo	Delete Every 2	Apply	Import Profile
		Total number of stations	79	ShiftZ 💌 0	Apply	Profiles On Topography
		Profile#	2	C All Profiles	Current Profile	Add Single Station
_		Profile Name	LINE1			C Replace C Insert
				0		× 900
Enable F	Profile Reordering	Station#	37	Join Profiles	Apply	Y 100
S P	×	Y	Z 🔺	Split Current Profile		Z 2
1 2	-900	100	2	after Selected station	Apply	
2 2	-850	100				
2 2			2	10000002-2000000000	0)	Add Loc
3 2	-800	100	2	Change Lungs	1	
32 42	-800 -750	100 100	2	Change LINE1	Apply	Add Loc Delete Loc
3 2	-800	100	2 2 2		Apply	
3 2 4 2 5 2 6 2	-800 -750 -700 -650	100 100 100 100	2 2 2 2			
3 2 4 2 5 2 6 2 7 2	-800 -750 -700 -650 -600	100 100 100 100 100 100	2 2 2 2 2 2	Generate Stations with Cor	nstant Step	
3 2 4 2 5 2 6 2 7 2 8 2	-800 -750 -700 -650 -600 -550	100 100 100 100 100 100 100	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	Generate Stations with Cor First Station	Last Station	Delete Loc
3 2 4 2 5 2 6 2 7 2 8 2 9 2	-800 -750 -700 -650 -600 -550 -500	100 100 100 100 100 100 100	2 2 2 2 2 2 2 2 2 2	Generate Stations with Cor	nstant Step	
3 2 4 2 5 2 6 2 7 2 8 2 9 2 10 2	-800 -750 -700 -650 -600 -550 -500 -450	100 100 100 100 100 100 100 100 100	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	Generate Stations with Cor First Station	Last Station	Delete Loc
3 2 4 2 5 2 6 2 7 2 8 2 9 2 10 2 11 2	-800 -750 -650 -600 -550 -500 -450 -40	100 100 100 100 100 100 100 100 100	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	Generate Stations with Cor First Station	Last Station	Delete Loc
3 2 4 2 5 2 6 2 7 2 8 2 9 2 10 2 11 2 12 2	-800 -750 -650 -600 -550 -500 -450 -450 -350	100 100 100 100 100 100 100 100 100 100	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	Generate Stations with Cor First Station	Last Station	Delete Loc
3     2       4     2       5     2       6     2       7     2       8     2       9     2       10     2       11     2       12     2       13     2	-800 -750 -650 -600 -550 -500 -450 -450 -350 -350 -300	100 100 100 100 100 100 100 100 100 100	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	Generate Stations with Cor First Station X -900 Y 100	Last Station X 900 Y 100	Delete Loc
3 2 4 2 5 2 6 2 7 2 8 2 9 2 10 2 11 2 12 2	-800 -750 -650 -600 -550 -500 -450 -450 -350	100 100 100 100 100 100 100 100 100 100	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	Generate Stations with Cor First Station	Last Station	Delete Loc

On the profile page, Input the starting and ending X, Y and Z positions of the profile as well as the number of data points. Then click the **New Profile** button. This may be done for several profiles if so desired.

*Note: For surface data, the profile must be placed above the surface interface e.g. at 0.01m* 

Enter the number of positions you would like to measure along the profile in the box labelled **Num. of stations.** 

For a profile 1000 m long with sampling positions every 25 m you will need 41 positions.

[Sampling stations= length of profile/sampling spacing + 1]

#### **Output Page**

Normalization Convention should be set to Absolute for Time domain calculations For Time Domain all normalizations are performed in the Transform module. Now the data channels must be selected. For time-domain data select:

### Fields: Scattered Host

Freespace

The modules to be used later will be able to calculate the Total and Total-Freespace from the above.

Click **Apply** to specify the model properties.

Layers	Page:
--------	-------

	Susceptibility	Resistivity	Density	Thickness	Configuration
	0	1e+009	0	1e+008	Survey Name Model 16
	Ö	25	0	1	
	0	100	0	160	Model Name Model16
	0	80	0	50	
	0	12	0	1e+009	Total Number of Layers 5
+					r Depth
					Top Depth 0
					lo l
	Save Model	Join Lay	ers	Split Layer	Bottom Depth
		123			
dit M	ode	Layer P	arameters		1
	Insert Layer			2	-Cole-Cole Polarization Mode Parameters
-		Layer	#	2	
	Replace Laver				C (exponent) parameter
_	Thephoto Callor	Resist	tivity (Ohm.m)	25	
					M parameter (chargeability)
	Delete Layer	Relati	ve Permittivity	1	
_	Donte Layor				T (time constant) parameter
	Undo Delete	Belati	ve Permeability	1	seconds
-			Ter territedunity		
			eptibility	0	Duran I Country Col Day Stor
	Restore	30600	phonet	·	Resistivity & Susceptibility Grid Data Files
_		Densi	ty (g/cm^3)	0	
		1 Dens	() () () () ()	0	
	<- Import Layers				View File
		1 Thick	ness (m)	1	Convert to GR9Z Delete File Loverist
	<- Import from a file				Convert to GPSZ Delete File Layer(s)

The first layer is set to air for you.

Air need not always be the first layer but must be included if part of the desired physical model.

Set the resistivity and thickness of your first layer ensuring that the insert mode is selected and "Add into the layer list".

Continue adding layers until you have a representation of your host rock. Set the thickness of the basement to something large, i.e. 1e8.

To edit layers once added, simply click on the layer in the top white box to select, make your correction to the resistivity and or thickness, then click Replace Layer.

To delete a layer click on the layer and click Delete Layer or use the delete key on your keyboard.

#### Prisms/Plates/Polyhedra Page:

This page allows access to the variety of simulation algorithms and interactions available in EMIGMA. In general, there are 3 basic modelling primitives - prisms, plates and polyhedra. These objects may have contrasts in either conductivity and/or permittivity from that of the background for EM applications and additionally contrasts in permeability (susceptibility) for Magnetics modelling. Multiple primitives may be considered by use of the "Prism Interactions".

	Conductivity	Susceptibility	Permittivity	Algorithm	Anomaly N	PolyF	File Name	☐ General Info	
	10	0.000000	1	LNPRISM	Plate1			Survey Name: Model Name	Meas Time
dit I	Mode	□ □ <sup>Target Pro</sup>	perties				View	Num	ber of Models 1
Re	nsert Target eplace Target <b>port Target</b>	Conduct	roperties ivity 11 ty (Ohm.m) 0. pility 1		Model Prism EiKPlate Poly C Sphere	- Scat. Algor C LN C ILN C VH C FS		ced	Rotation (degree)- Euler Angles 1st 0 2nd 0 3rd 0
	Shift Target Delete	Suscept	· _		- Center/Top Lo	cation	Scale Factor (m	)	Geological Angle
L	Indo Delete				Y .32		Dip Extent	12	Dip 0
1	Import Fopography Restore	C (expor dimensio M (charg dimensio T (time o seconds	nent) 0 nless 0 nless 0 nless 0 constant) 0		Z16 C Center Poly Filename	⊙ Top	Thickness 4		Plunge 0

Model

Select Prism, EiKPlate or Poly

Scattering Algorithm

select LN for current channelling responses of prisms select ILN for current channelling and weak induction of prisms select VH for channelling and induction of a thin sheet select FS for induction of a thin sheet

If you are not sure whether the response is dominantly currently channelling or induction, or whether both are important in the response, you can run different algorithms to determine this. For example, if VH and FS give similar results, then the response is dominantly induction. Please refer to the main EMIGMA manual for a description of the different scattering algorithms.

#### Scale Factor:

Input the width (X), length (Y) and height (Z) of the body

These may be considered as the Strike, Dip Extent and Thickness of the object. Refer to the main

EMIGMA manual under VHPLATE for help in this respect.

#### Centre/Top Location

Input the centre of mass or top position of the body:

#### Rotation (Prism/Plate)

Input the rotation/prisms (Euler Angles) Refer to insert in the main manual on Euler Angles for instructions on rotation your body

For a Plate use strike and dip angles. Refer to main manual

#### **Target Properties**

Input the conductivity (or resistivity) of the body.

For VHPLATE, the conductance = the conductivity times the thickness of the target (Nominally 0.01m), thus for a plate with a conductance of 20S/m, use a conductivity of 2000S. One may also indicate here a variation in permittivity.

For Magnetics modelling indicate either the permeability (here this is relative permeability) or the susceptibility

Note: The user is able to use variations in all material properties.

#### Internal Current Sampling

Input the number of sampling points you would like to calculate

VHPLATE defaults the number of sampling points to 441. You cannot change

this.

LNPRISM defaults the number of sampling points to 100. Up to 600 may be used per prism

ILNPrism calculates 7 positions in a cluster around each sampling position. The default is set to 40 sampling points. Normally 20 sample points is sufficient. At this time, the maximum sample points is 85.

Cole-Cole Parameters:

At any time, whether for IP or EM, the user may specify the Cole-Cole parameters m,c,tau for any of the scattering objects.

Inserting an Anomaly:

Click **Insert Target**. Repeat process to add multiple bodies. Note that you can use more than one algorithm in the same model and that you do not need to use the same sampling points for each body.

Prism Interactions - Available to clients who are licensed:

To model the response over multiple bodies, you can now choose the type of interaction. The default is set to near field (assumes electrical contact between the bodies). If you would like to change it to either far field (interaction of bodies not in contact) or superposition (simply addition of the response of two non interacting bodies) you can click on **Interactions** and select one of these.

**Editing Prisms/Plates** 

To edit a prism or plate simply double click on the body in the top white box to select, make necessary changes and click the **Replace Target** button. To delete a prism click on the body and click **Delete** or use the delete key on your keyboard.

Click **Apply** to see the new data set in the main EMIGMA database window.

#### **Confirm your model in the Visualizer before Calculations:**

It is generally useful to view your model in the Visualizer prior to computing the model. In the visualizer you will be able to make modifications or more accurately specify your model.

Anomaly Properties		
Set Anomaly Positions	Dimensions (m) Strike Length 300	
C Shift Anomaly	Dip Extent 200	
Center/Top Position (m)	Thideness 0.01	
North 20100.02	Geological Angles (Degree)	
East 325	Strike 90 Dip -75	
C Center C Top	Plunge 0	
Material Properties	Number Of Sample Pts 441	
Conductance (s) 20 Susceptibility (k) 0	Anomaly Name	
Permittivity 1 Resistivity (ohm-m) 0.0005	Model tem5_vh5_20:	
Density (g/cm^3)	All parameters are in SI units	
Cole - Cole	Constant Color	
С М Т(s)	Color	
Apply Und	Close	

With the data set of your model selected, open VisRD with the Viz button on the toolbar.

Using the hand and bottom left dial bars you can manipulate the view of your model in 3D space. The right bottom dial bar and slide bar are zoom controls.

#### Editing your model

With the arrow, click on your model once, right click, select edit, select properties page. You can now edit your model parameters in the same way as you did before.

If you make changes to your model, click the **Save to Database** button.

#### **Forward Simulation**

Click the *local* button on the main EMIGMA toolbar.



A page is displayed indicating progress through frequencies, components, and profiles. Click **Run Simulation** to begin

### **Frequency to Time Domain Transform.**

Select the sprectral domain data set and start FSEMTRS with the **Derivative** button on the main EMIGMA toolbar. The first page in the Wizard appears like this: Input the base frequency for your system. If you wish dB/dt select Time Derivative. Select **Next**.

General input				×
Input data from data	abase C Ana			
Base Frequency (Hz)	80			
Base Period (msec)	33.3333			
Number of Odd Harmonic	× 4096			
Maximum Harmonic (Hz)	245730			
Time Derivative	V			
🗖 Use amplifier		1		
	< Back	Next >	Cancel	Help

Accept the defaults for low pass filters and click Next.

ilter —	
M 4	Apply Frequency Filters ?
	Low Pass Filters
	Apply Low Pass Filters
	C Bessel Low Pass Filter
	Cut-off Frequency for Filtering 25000
	Order (poles) of filter 7
	C Lancos Damping
	Notch Filters
	Apply Notch Filter
	Filter # 0
	Notch Frequency
	Notch-Width for Filtering
	<back next=""> Cancel Help</back>

Choose Generalized square waveform for the Crone system and Next.



Input the rise time constant (1 msec is used as a rough approximation for many systems). Input the linear ramp time: (1.25 msec)

Off-time: Off-time is calculated assuming ramp begins at a 1/4 cycle. If this is not correct then input a different Off-time.

Waveform Type: General Square Wave	
Half Period (msec)	16.6667
Exponential Rise Time-Constant (msec)	1
Turn-off Time (linear ramp) (msec)	1.25
Frequency for Sine On/Off (Hz)	0
Time for Sine On/Off (msec)	0
Off-time per 1/2 cycle (msec)	7.08337
Ramp Turn-off Begins at (msec)	8.33333
	Normalize
< Ba	ck Next > Cancel Help

#### Browse for a windows parameter file in EMIGMAVX\TimeChannelFiles Use wcrone20\_15Hz.par for a 15Hz base frequency system. Or create your own windows.*Note:*

izing			
Time-channel Parameter File     Time-channel from Survey	Center of Time Window Is		
	Browser		
Time origin on parameter file at:	Generalized square wave		
1/2 Sine or Triangle Pulse	C Begining of Ramp Off		
C Begining of Pulse	End of Ramp Off		
C End of Pulse	Delay Time (msec)		
Create/Edit Time Windows	View Time Windows		
Digitize time-channel values ?			
Number of points for Digitizing per	Half-Cycle		

equency system. Or create your own windows.Note: You may view the time channels here using the Retrieve Data button. You may edit the time windows using the Create/Edit button.

Under Generalized Square Waveform, select end of ramp off as the start time for the channels, the primary pulse will be negative before this all time channels will be positive,

Click Next.

Select nanoTesla/sec (B) for the units.

Check the Data set name is as you wish.

Click Run.

Data set name: Simu Time		
Current Status:		Absolute
tax frequency (Hz): lumber of frequencies: Run	Show Warnings	Output fields Total Total-Freespace Total-Freespace (Analytic) Scattered Host or Background FreeSpace Units for H-Dipole (Absolute) Amps/m/s (H) nanoTesla/s (B) pT/s

Upon Successful completion you can click Finish.

You may then continue with plotting and displaying the results.

## Plotting Measured and Simulated Data -

Start dbPlotter by clicking the button on the main EMIGMA toolbar.

#### Configuring your plot

Survey - if you have more then one survey in the file choose the survey you wish to plot

Profile - if you have more then one profile in the file choose the profile you wish to plot.

Use profile name or the Axis which determines the profile line to see which profiles correspond with which numbers. For a profile running North South, the X axis will tell you the start X position of the profile which is usually the line name.

Domain - Use Profile to plot the data as a function of position.

- Use Decay to view the decay of the data as a function of time.

Channel Selection		Channel - After channel selection
Indicate Channels	Field	under configuration or using the hot
Plot # Time (mSec)	Image: Second secon	keys - Click on the first white box under Plot #
		<ul> <li>Select the time channel by clicking on the black triangle</li> <li>Click on the yellow question mark under field.</li> </ul>
9	Chargeability 🗖 Derivative	
□ 10 <u>·</u>	Clear All Selections	
11       12       13       14       15	General Information	Select the fields, component and measured or simulated data. Use fields available to view data contained in the file.

Click OK

#### Additional Tools available in EiKPlot as buttons.

Hold your cursor over the centre of the button to read the tooltips.

#### Printing:

Printing is available as in any standard Windows application.