Fall-Of-Potential Calculations Using MALZ

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As a means to check the validity of the soil and ground grid model used in a grounding analysis study, the calculated fall-of potential curve is compared to the measured curve. The CDEGS MALZ module is generally used for large systems grounding analysis. Unlike MALT, MALZ does not have a built in feature to calculate fall-of-potential plots. This article will focus on the procedure on calculating a fall-of-potential plot using MALZ.

To illustrate the process, data taken from a medium sized substation, Station "OK", is used. The size of Station "OK" is 250 ft. X 215 ft. Figure 1 shows the general layout of the station grounds and equipment. Figure 2 shows where the soil resistivity and grid resistance fall-of-potential measurements were taken.

With soil resistivity data taken with a Megger DET-2/2 soil resistance meter, a four layer soil model is derived with RESAP. Figure 3 shows the RESAP plot. The calculated curve is very close to the measured curve.

In energizing the MALZ model, 1 amp was injected at a location inside the station yard. In addition, 1 amp was returned at the remote stake. Figure 4 shows the command mode portion of the MALZ file and Figure 5 to Figure 6 depicts the screen shots of the Input Toolbox for the same input file illustrating the different settings used. Profile points were taken at the surface along the fall-of-potential path at 25 ft. intervals for a total of 950 feet. The starting and ending frequency was set to 150 Hz, the same frequency used by the meter at the time of the measurement.

Once the MALZ run is completed, the potential rise of the injected conductor is noted from the F09 output file. In this case, the potential rise is 0.3743 volt with a 169.16 degree angle. From the Output Toolbox module of the plot/report portion of CDEGS, touch potential is computed using the potential rise magnitude and angle as the user defined values with a setting for 2D plots. Figure 9 shows the Output Toolbox Computation screen.

Before clicking on the draw button, some flags need to be made under the Advance setting in order to save the report file. Click on advance button on the Computation screen and then check the selection for "Generate Report on to File" with the selection of "All Selected Points". Figure 10 shows the Zoom and Profiles tab settings. Click on OK to return to the main menu and click on the draw button. Under the plot tab, a fall-of-potential curve is created and under the report tap, the touch potential points are listed. Figure 11 shows the resulting profile plot. This should look like a typical fall-of-potential curve. After closing up the Output Toolbox, the report files are saved as a CS_XXXX.F17 file where XXXX is the run ID.

From here, I can now plot the measured fall-of-potential resistance data versus the calculated points. Using the plotting feature in Microsoft EXCEL, three columns are listed. The first is for distance, second for the measured data and last is for the calculated data. One thing to note is that the calculated results from MALZ are in volts. Since I used 1 amp as my injected current, the resulting touch voltages are the same as the point resistances.

Figure 12 shows the resulting curves. This case, the curves match closely. So, this appears to be a valid model. Several things to consider in the event that the match is not close may be due to poor ground grid model, bad soil resistivity data, or grid resistance data. The bad data may be caused by buried pipeline interference or even coupling between the probe leads.

In closing, background information on measuring and hand plotting the grid resistance of a station is covered in the "How To...." engineering guide on large suburban stations (SUBURBAN.PDF) as well as several other publications.



Figure 1 General arrangement of equipment and ground grid of Station "OK"



Figure 2 Location of fall-of-potential and soil resistivity measurements



Layer Number	Resistivity (ohm-m)	Thickness (Feet)	Coefficient (p.u.)	Contrast Ratio
=====		================	============	=============
1	infinite	infinite	0.0	1.0
2	23.80000	7.500000	-1.0000	0.23800E-18
3	15.00000	13.30000	-0.22680	0.63025
4	261.8000	56.10000	0.89162	17.453
5	10.30000	infinite	-0.92429	0.39343E-01

Figure 3 RESAP plot

```
MALZ
TEXT, Simulation of Step and Touch Potentials at Station "OK".
TEXT, Four layer soil model. - Traverse 1
TEXT, Fall-of-Potential Curve
OPTIONS
  UNITS, INCH-RADIUS
  RUN-IDENTIFICATION, OLDOB
SOIL-TYPE, MULTILAYER
  HORIZONTAL
    LAYER, TOP, 23.8, 7.5
    LAYER, CENTRAL, 15.0, 13.3
    LAYER, CENTRAL, 261.8, 56.1
   LAYER, BOTTOM, 10.3
COMPUTATIONS
  DETERMINE, POTENTIAL
  OBSERVATION-POINTS
    PROFILES, 39, 265., 110., 0., 25., 0., 0.
  FREQUENCY, 150, 150
SYSTEM
  ENERGIZATION, REFERENCE, 1.,
  ENERGIZATION, ,-1.,
SYSTEM
  NETWORK
    MAIN-GROUND
      CONDUCTOR, 0, 0, 0, 1, 216.5, 118.5, 1.5, 214., 118.5, 1.5, .2875, 1
      CONDUCTOR, 0, 0, 0, 2, 1215., 110., .5, 1215., 110., 1.5, .3125, 1
      CONDUCTOR, -1, 0, 0, 0, 111., 112., 1., 111., 127., 1., .4065, 1
                     "
                                w
            "
w
          "
       CONDUCTOR, -1, 0, 0, 0, 48., 203., 1., 48., 192., 1., 2875, 1
ENDPROGRAM
```

Figure 4 MALZ command mode input file

Lase <u>Description</u>				
Module Description		Project Description		
Simulation of Ste Four layer soil me Fall-of-Potential	p and Touch Potenti odel Traverse 1 Curve	als at Station "OK"		
Run- <u>I</u> dentification • Use JobID • Specify FOPSimulation		System of Un Metric • Radius in II	its British nches	
)e <u>f</u> ine System <u>S</u> oil Type	Allow Large Ra <u>P</u> rintout O Detailed C Semi-Detailed	dius (> 39.4 in.)	<u>New Case</u> Sa <u>v</u> e Load	

Figure 5 Screen shot of the main MALZ Input Toolbox screen

nerg C	ization Sourc artesian C	ce (Bus) Curre <u>P</u> olar	nts or Volta	je		Bus In+jIn /(2
Bus	Identification	Energization Type	Real Part (Amps)	Imaginary Part (Amps)	-	ANDER
1	Source-SES	Current	1.			17-1-
2	Source-SES	Current	-1.		1	- Reference Rue
3						nelelence bus
4						Last Bus 🔻
5						
6						Reference Conductor
7						Conductor No. @ Origin
8						C End
0						

Figure 6 Screen shot of the MALZ energization system settings



Figure 7- Screen shot of the MALZ soil type settings

120								
Comput Compu	te gnetic Field h et (ft.): gnetic gnetic (A/m): files	ial J Points	Y4	d origin dZ forigin	X	dX rigin 2 V	rofile	X
Show P	rofiles & C	onducto		ti Show Pro	L Elec		cal la	
Profiles	Number of Points N	Xorigin (Feet)	Yorigin (Feet)	Zorigin (Feet)	d× (Feet)	dY (Feet)	dZ (Feet)	Define Surface
Profiles P1 P2 P3 P4 P5	Number of Points, N 39	Xorigin (Feet) 265.	Yorigin (Feet) 110.	Zorigin (Feet) 0.	dX (Feet) 25.	dY (Feet) 0.	dZ (Feet) 0.	■ ▼ Define Surface S1 [S2 [S3 [S4 [S5 [
Profiles P1 P2 P3 P4 P5 Ereques © Sing © Mult	Number of Points, N 39 ncy gle tiple Ba	Xorigin (Feet) 265. Ingle Fre tart Frequesse Frequess	Yorigin (Feet) 110. quency – uency (H uency (H	Zorigin (Feet) 0. z): 150. z): 150.	dX (Feet) 25.	dY (Feet) 0. Multi	dZ (Feet) 0. iple Frec	Define Surface S1 S2 S3 S4 S5 Tuencies

Figure 8 Screen shot of the MALZ computation settings

aner (comparations)			
Computations	C Configuration	Adyanced	<u>o</u> k
lot Title		Setup	<u>C</u> ancel
Station "OK" Fall-of-Potential Cu	rve		
eport Computation res <u>u</u> lts for		Safety	Heset
Scalar Potentials	-	Report	Dra <u>w</u>
Determine		Cumman -	
Touch Voltages	-	Summary 💽	
Reference GPR for Touch Vol	tages	Screen -	Screen
User Defined	•		
Reference GPR Magnitude (Ve	olts): 0.3743	<u>R</u> eport	<u>D</u> raw
Reference GPR Angle (Degree	es): 169.16		
Search Radius for Reference	GPR (ft): 9.84	- Energization S	caling Factor
requency			
No. 1: 60 💌	Hz <u>S</u> elect	Not Applied	Define
lotting Threshold		- Vi <u>e</u> w	
C Use Safety Limit		C 2D	
User-Defined Threshold		C 3D Persp	ective
Touch Voltage(Volts)		C Contour 2	20
Touch Voltage(Volts) Get Threshold From S	afety Table	Contour 2	20
Touch Voltage(Volts) Get Threshold From S. Isplay Along the Y Axis	afety Table	C Contour 3	2U Customiza
Touch Voltage(Volts) Get Threshold <u>From S</u> Tisplay Along the <u>Y</u> Axis Magnitude (Volts)	afety Table	© Contour 2 © Spot 2D	Customize
Touch Voltage(Volts) Get Threshold From S. Visplay Along the Y Axis Magnitude (Volts) Gauss C Real	afety Table Reference GPR	C Contour :	20 Customize pose Grid
Touch Voltage(Volts) Get Threshold From So Visplay Along the Y Axis Magnitude (Volts) Gauss C Real Milligauss C Imaginary	afety Table Reference GPR Magnitude (Volts):	C Contour 2 ⊙ Spot 2D ✓ Super Configu	2D Customize pose Grid iration
Touch Voltage(Volts) Get Threshold Erom S. Sisplay Along the Y Axis Magnitude (Volts) Gauss C Real Milligauss C Imaginary Tesla C Angle (Deg)	afety Table Reference GPR Magnitude (Volts):	C Contour 3 C Spot 2D ✓ Super Configu ✓ Preser	Customize pose Grid rration ve Geo-
Touch Voltage(Volts) Get Threshold From S. Visplay Along the Y Axis Magnitude (Volts) Gauss C Real Milligauss C Imaginary Tesla C Angle (Deg) MicroTesla C Percent	Angle	Contour : Contour : Spot 2D ✓ Super Configu ✓ Preser metry F	2D Customize pose Grid gration ve Geo- Proportion

Figure 9 Output Toolbox Computation Screen

oom and Profiles <u>E</u> xport Database Results	:			
Formatted Reports Generate Report to File Generate Report to Screen	Zoom and Profile Selection Points Start: End:			
All Selected Points	P <u>r</u> ofiles Number of Profiles: 131			
All Selected Points N Lowest and Highest Values Values Exceeding Safe Limits All Above Options	Start End Range 1	< III >		
Safety Limit Touch Voltage (Volts): 367.9	Range 3 Range 4	~		
<u>G</u> et Threshold From Safety Table	Define Zoom Area			
Export Raw Data to File	Automatic Zoom			
Delimit Data by	Search-Zone Vertices:			
🤨 Comma 🔿 Tab 🔿 Blank	XPos YPos ZPos Point 1 Point 2			
✓ Include Title and JOBID Proceed	Point 3 Point 4	~		

Figure 10 Advance Computation Screen



Figure 11 Potential Curve



Figure 12 Fall-of-Potential curve comparison.