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Risk in Design, Construction & Testing of a Grounding System

CIGRE-IEC 2016 Colloquium – May 10th, 2016

Objective

The objective of this presentation is to identify and assess the risks associated with various errors and omissions that could be introduced during the

- Design,
- Construction, and
- ~~Testing stages~~

Of a grounding system.

Types of Ground Grids Under the Study

- Ground rod
- Small ground grids 25 to 50 m^2 (250 to 500 ft^2), typical of small distribution stations.
- Medium ground grids 100 to 200 m^2 (1000 to 2000 ft^2), typical of large distribution stations or smaller transmission stations.
- Large ground grids larger than 200m^2 (2000 ft^2), typical of larger transmission or terminal stations.

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Risk Associated with Errors due to Design

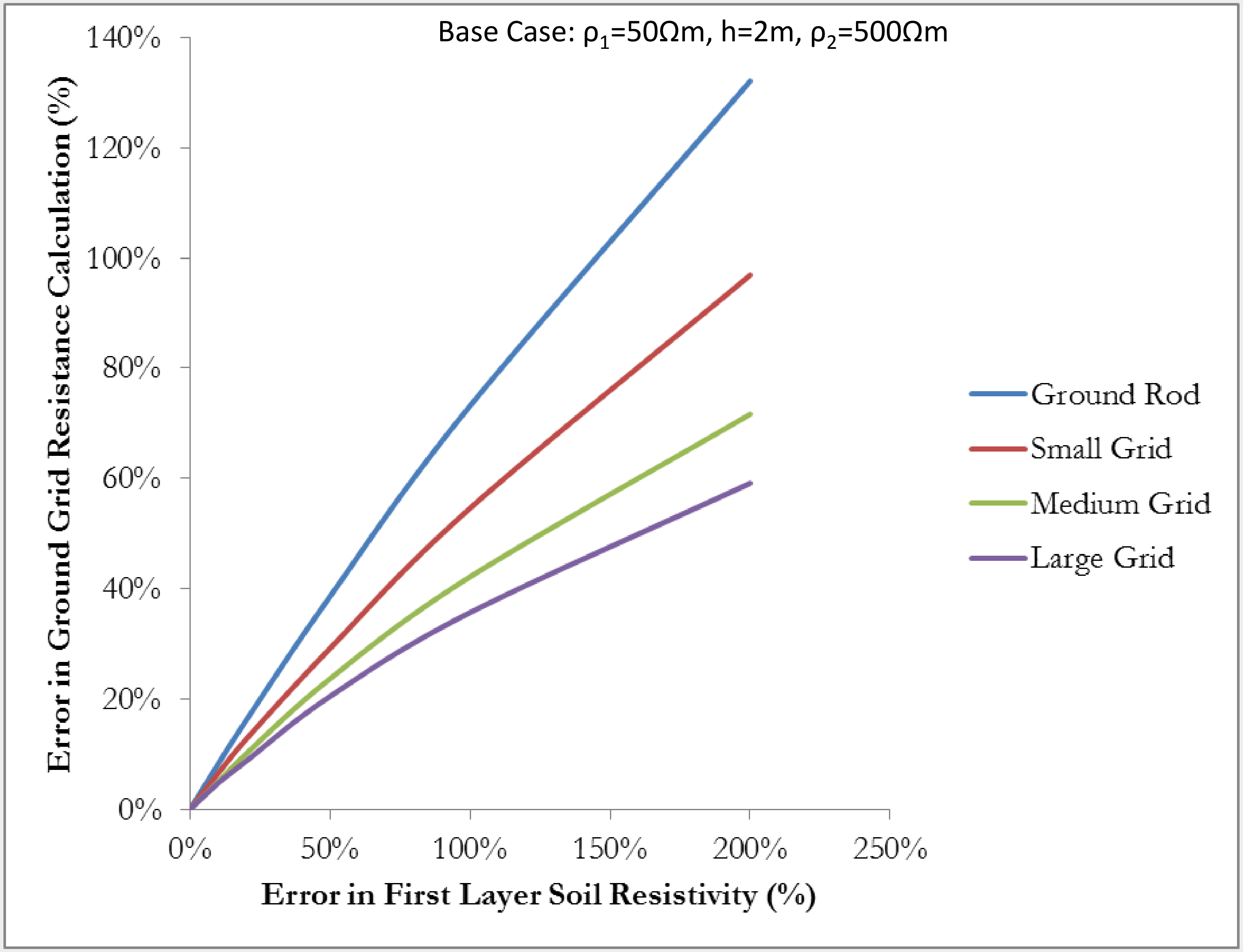
Errors Due to Uncertainty in Resistivity Value

Importance of the resistivity value

- impacts the size of the grounding electrode required to limit the potential rise at a given fault level.
- controls the number of conductors required to limit step and touch potentials.
- affects the resistance under the foot, which leads to the safe body withstand

Errors Due to Uncertainty in Resistivity Value

error in accurately capturing resistivity of the top layer

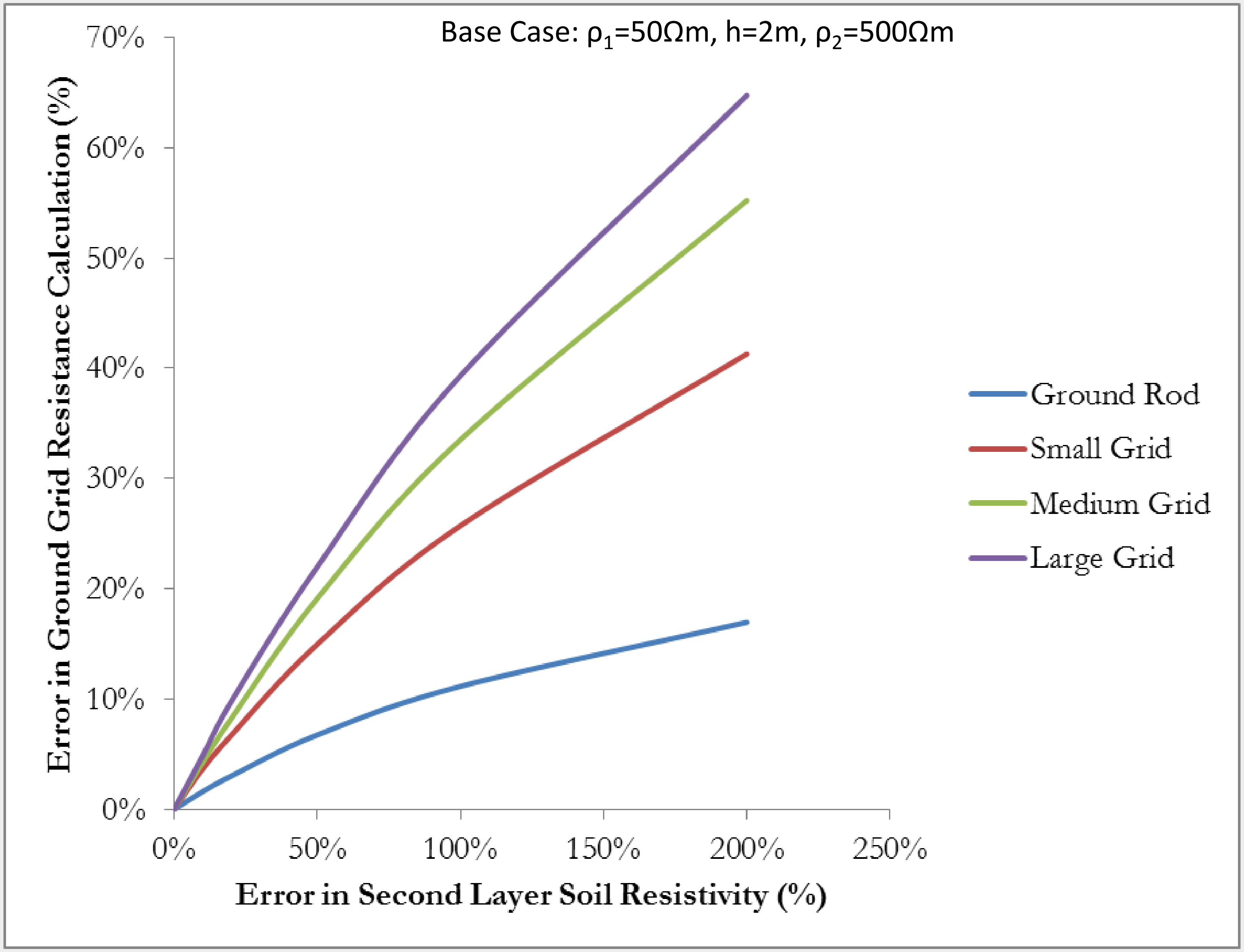


A 200% error in accurately defining the first layer soil resistivity results in the following errors in calculation of the grid resistance:

- Rod: 132%
- Small Grid: 97%
- Medium Grid: 72%
- Large Grid: 59%

Errors Due to Uncertainty in Resistivity Value

error in accurately capturing resistivity of the bottom layer



A 200% error in accurately defining the second layer soil resistivity results in the following errors in calculation of the grid resistance:

- Rod: 17%
- Small Grid: 41%
- Medium Grid: 55%
- Large Grid: 65%

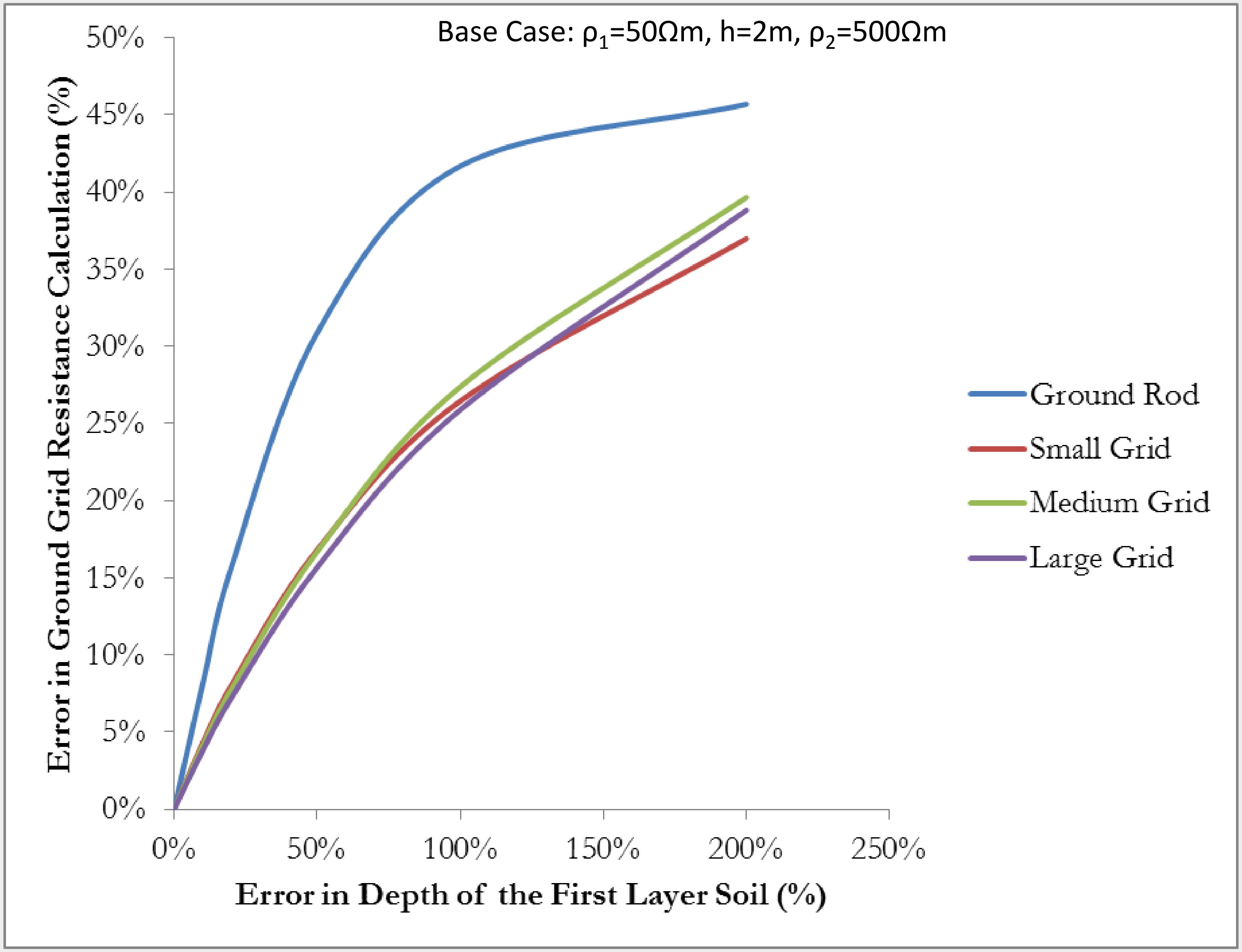
Conclusion:

In large grids, the bottom layer soil resistivity is the important quantity.

In small grids, correctly capturing the first layer soil resistivity is more important than the bottom layer.

Errors Due to Uncertainty in Resistivity Value

error in accurately capturing depth of the top layer



A 200% error in accurately defining the first layer depth results in the following errors in calculation of the grid resistance:

- Rod: 46%
- Small Grid: 37%
- Medium Grid: 40%
- Large Grid: 39%

Conclusion:

Leaving ground rod aside, the error associated with correctly capturing the depth of the first layer is the same no matter the size of the grid.

Errors Due to Consideration of LG vs LLG

- There are only two fault types that result in ground current:
  - single line-to-ground fault
  - double line-to-ground fault.
- In order to determine the maximum ground current in an isolated grounding system, zero sequence current during either of the above mentioned fault types need to be calculated, and the maximum value used for ground grid design.

Errors Due to Consideration of LG vs LLG

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Scenario #	1	2	3	4
Voltage Level (kV)	230	230	230	230
Three Phase Fault Current (A)	10,000	10,000	20,000	20,000
Single Phase Fault Current (A)	6,000	12,000	12,000	26,000
Ground Current Single Phase-to-Ground Fault (A)	6,000	**12,000**	12,000	**26,000**
Ground Current Double Phase-to-Ground Fault (A)	4,300	**15,000**	8,600	**37,000**

Conclusion:

When the amount of three phase fault current is less than single phase current, the "ground current" under double line-to-ground fault is more than the "ground current" under single line-to-ground fault

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Risk Associated with Errors due to Construction

Errors Due to Placing the Grounding Mesh at a Different Depth

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The ground grid is typically buried at the depth of 300 to 600 mm (12” to 24”) below the grade level. At the design stage, the grounding software calculates resistance of the ground grid based on the burial depth proposed by the designer.

Because of construction constraints, it is quite common for the burial depth to be different from that specified during the design

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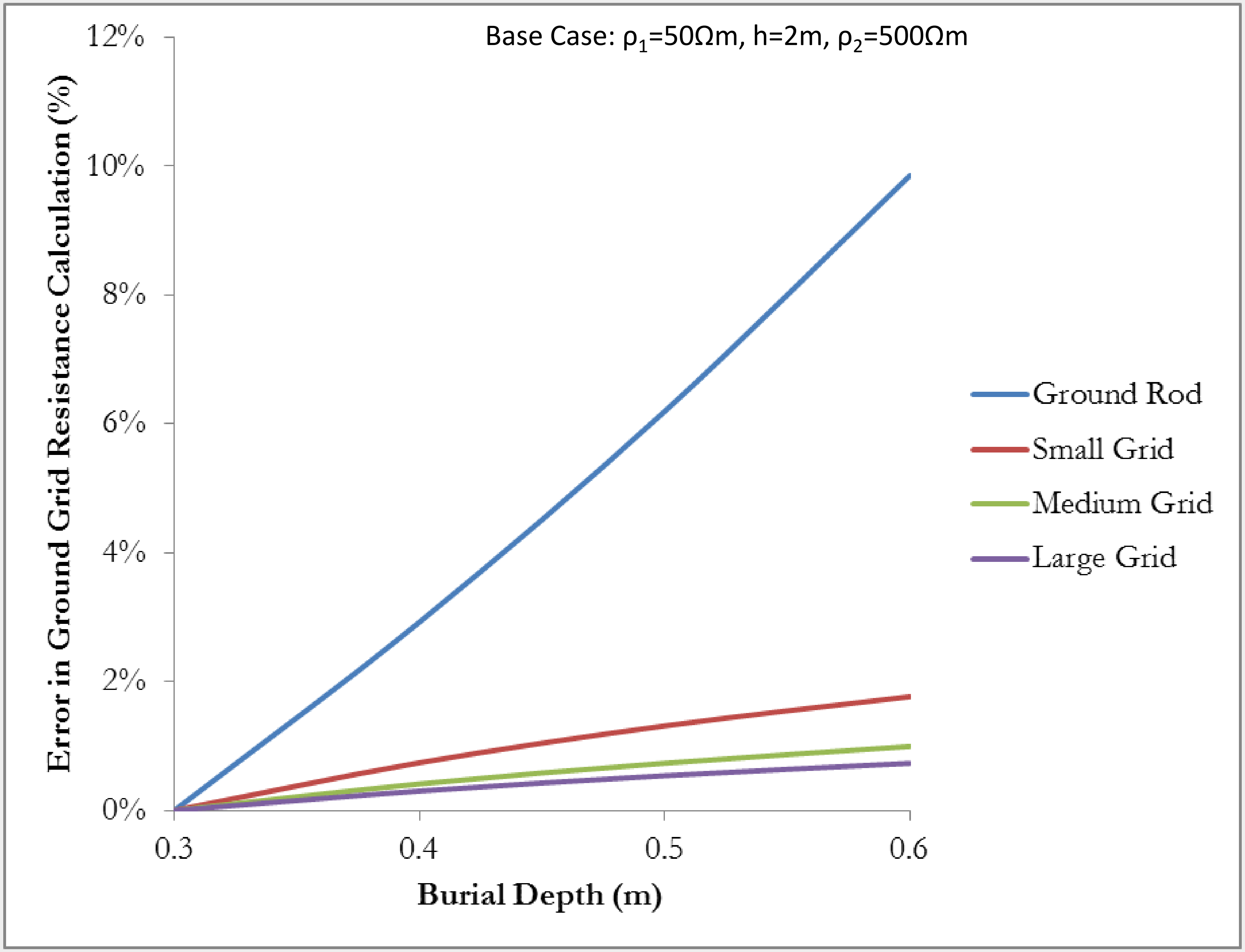
Errors Due to Placing the Grounding Mesh at a Different Depth



Conclusion:

If we change the depth from 0.4m to 0.6m, we will get an error of about 1%. This graph shows that the burial depth of the ground grid does not play a critical role in calculation of the grid resistance

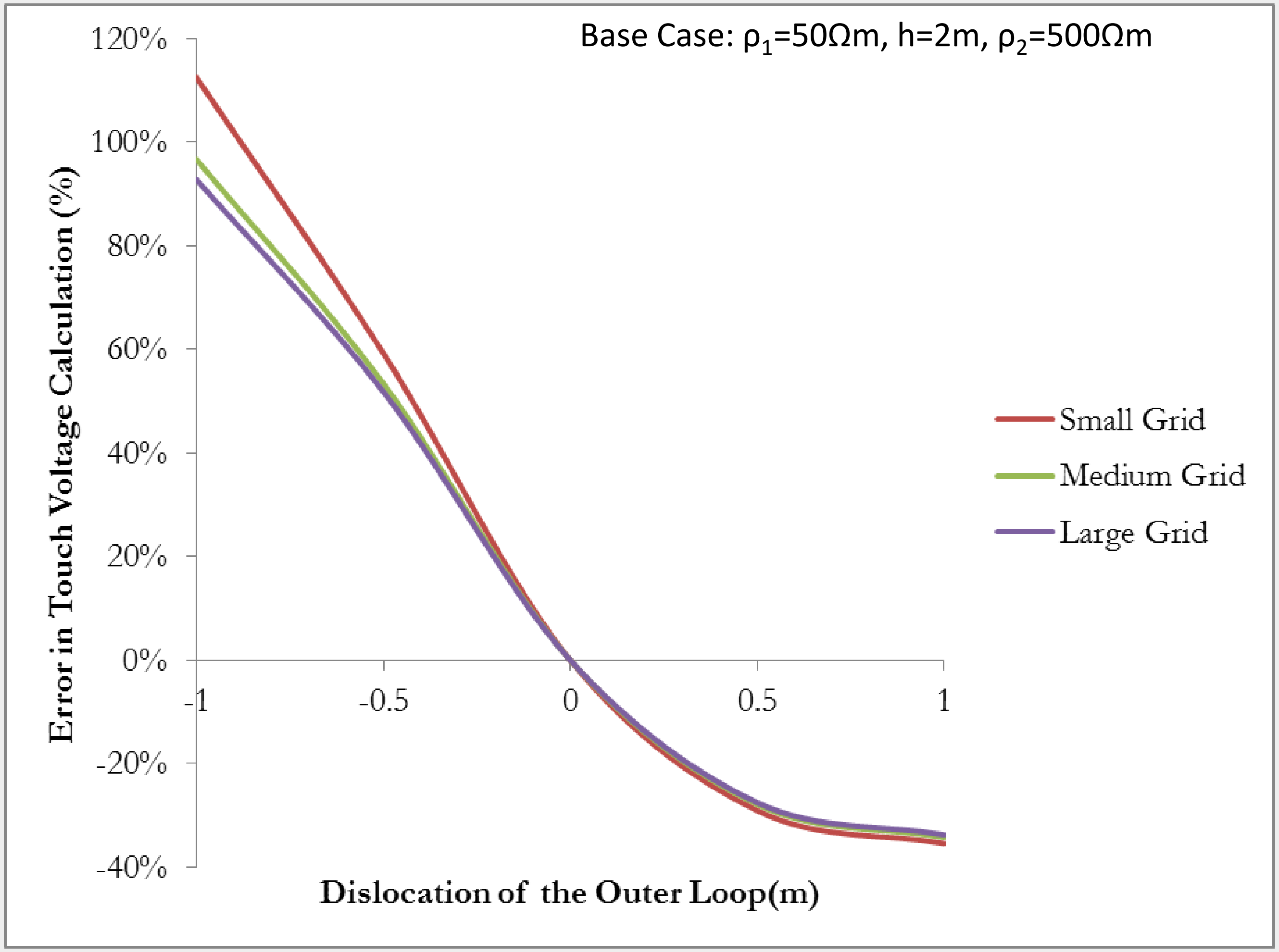
Errors Due to Placing the Grounding Conductor at a Different Location

Relocation of the ground grid conductors will essentially impact the touch potential and not the ground grid resistance.

Relocation of the conductors

- Inside of the fenced area (Inner loops): the effect is negligible
- Near the fence (outer loop): Significant error on fence touch potential values

Errors Due to Placing the Grounding Conductor at a Different Location



0 = the outer loop is positioned at the location defined by the designer.

-1 = the outer loop is located inward by a distance of 1 m

+1 = the outer loop is located outward by a distance of 1 m.

Conclusion:

If we move the outer loop inward by 0.5m, the touch potential value increases by about 60%. Hence, it is pretty important to place the <u>outer loop</u> at the location dictated by the designer.

Thank You

Babak Jamali, METSCO
babak.jamali@metsco.ca

Byron Ma, METSCO
byron.ma@metsco.ca

Alex Mogilevsky, CEATI
alex.mogilevsky@ceati.com