Earth Potential Rise in Public Spaces Near Telecommunications Facilities

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Acknowledgements

- Copyright of IEEE, Intelec 2018 Conference
- Authors: Rohit Narayan & Smitha HarshaVardana, nVent ERICO
- Gary Graham, Principal, Eagle Electromagnetic Design Services Pty Ltd, Adelaide Australia provided guidance on modelling of complete power system
- Saman DeSilva, Principal Engineer Standard at SPAusnet Pty Limited, Melbourne Australia provided guidance and expected fault currents at various locations with a power utility network.

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Content

- Examples of telecommunication facilities in public spaces
- Effect of a direct lightning strike to a telecom tower on nearby facilities
- Effect of AC ground faults at power transformers on nearby telecommunications installations
- Examples of modelling to show GPR, Step Voltage and Touch Voltages from AC Faults on nearby transformers

Why The Concern for GPR is New?

- The traditional telecommunications networks were housed in buildings and in shelters and cabinets in well gated areas, often several hundred meters or more away from areas of very dense populations.
- The new word in telecommunications is densification. The densification of the network also means that in the modern telecommunications network, telecommunications facilities are closer to the public domain and often in densely populated areas.
- Examples of such infrastructure could include small cells, macro cells, fiber cabinets and other facilities.
- New considerations must be given to the earth potential rise that can occur at or near a telecommunication facility that is close to power utility assets and consumers.

Examples of Telecom Equipment Near Public Domain




Small Cells on Poles – Notice one on right on same pole as pole mounted utility transformer

Examples of Telecom Equipment Near Public Domain

Cell tower in close vicinity to an electrical substation

Cell tower in close vicinity to dwellings

Examples of Roadside Utility Transformers

Ground Potential Rise, GPR Due to Lightning Near Telecom Towers

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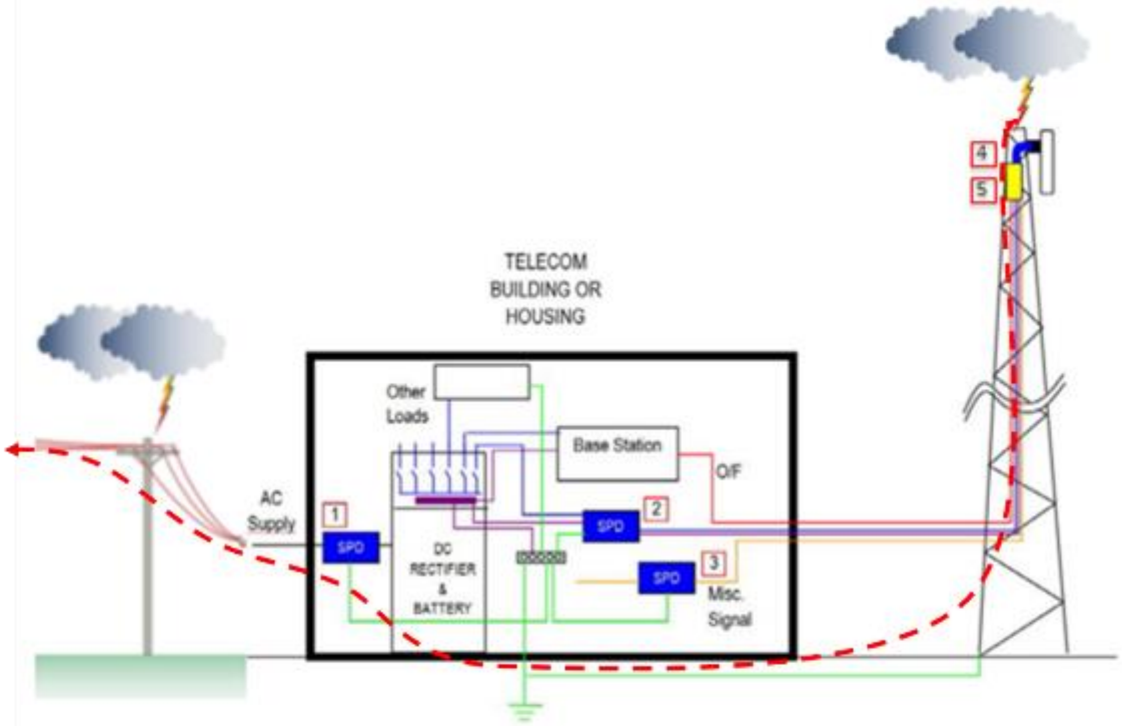
Lightning Strike on Telecom Towers

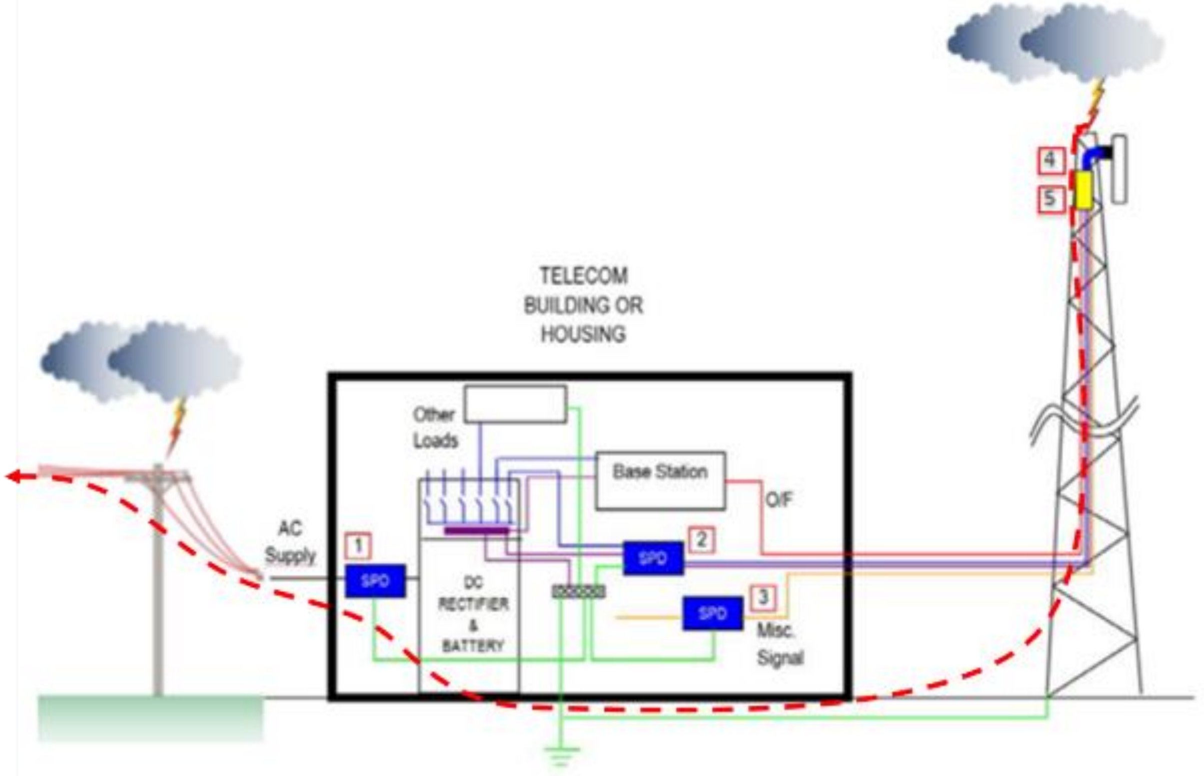
Direct & Induced

The lightning to the tower can cause induced and direct coupled currents in the incoming power lines, which are inherently connected to nearby dwellings through the main power reticulation. These can travel in both directions on power lines and travel to switchboards and the earthing system of the near by dwellings.



Solutions to minimise effects of surges

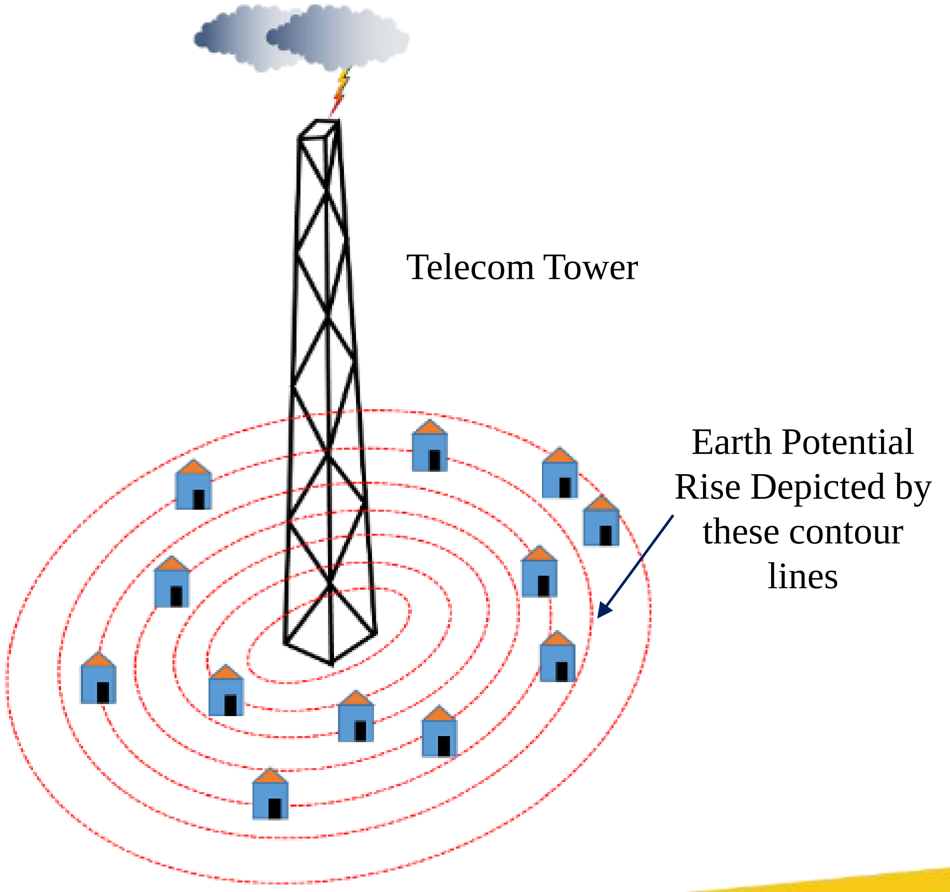
- Install appropriate SPD or TVSS in locations 1, 2 and 3
- Install SPD at main switch boards of nearby facilities
- Low resistance (impedance) grounding electrode at cell site



Lightning Strike on Telecom Towers

EARTH POTENTIAL RISE

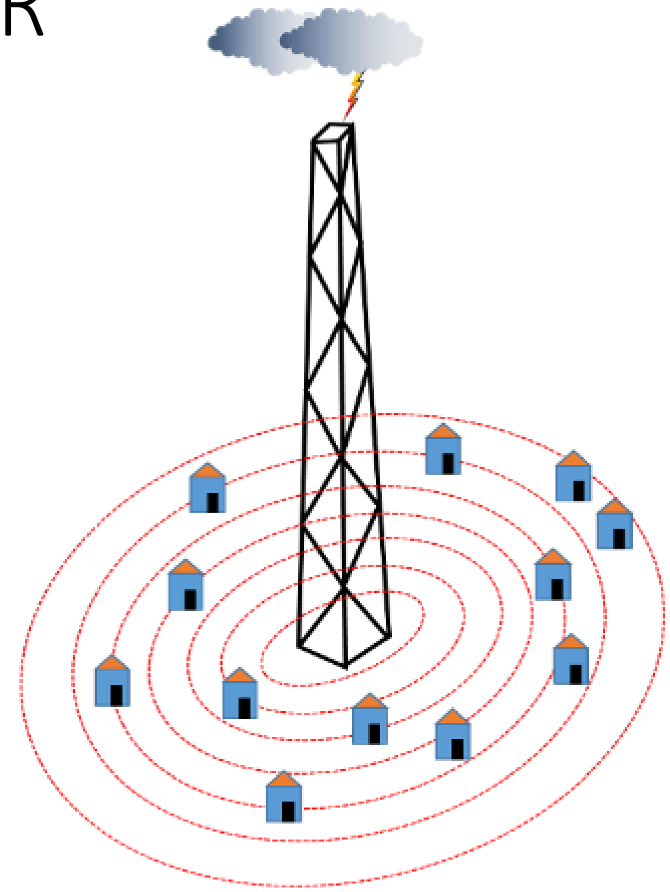
- The large amount of lightning current injected and dissipated in the earth near the tower can cause severe EPR which can drastically increase voltage gradients in the earth hence finding its way through the neutral and the earth electrodes into nearby dwellings



Solution to minimise effects of GPR

- Low resistance (impedance) grounding electrode at cell site

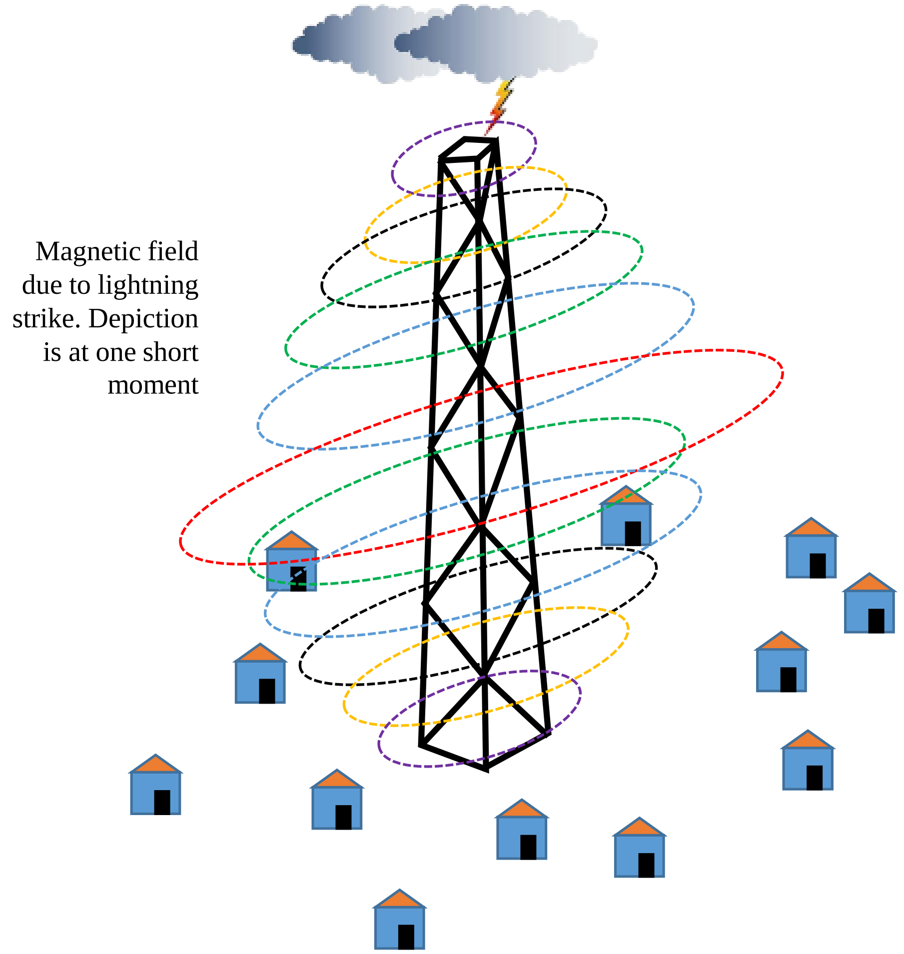
- Ground rings around nearby facilities if possible



Lightning Strike on Telecom Tower

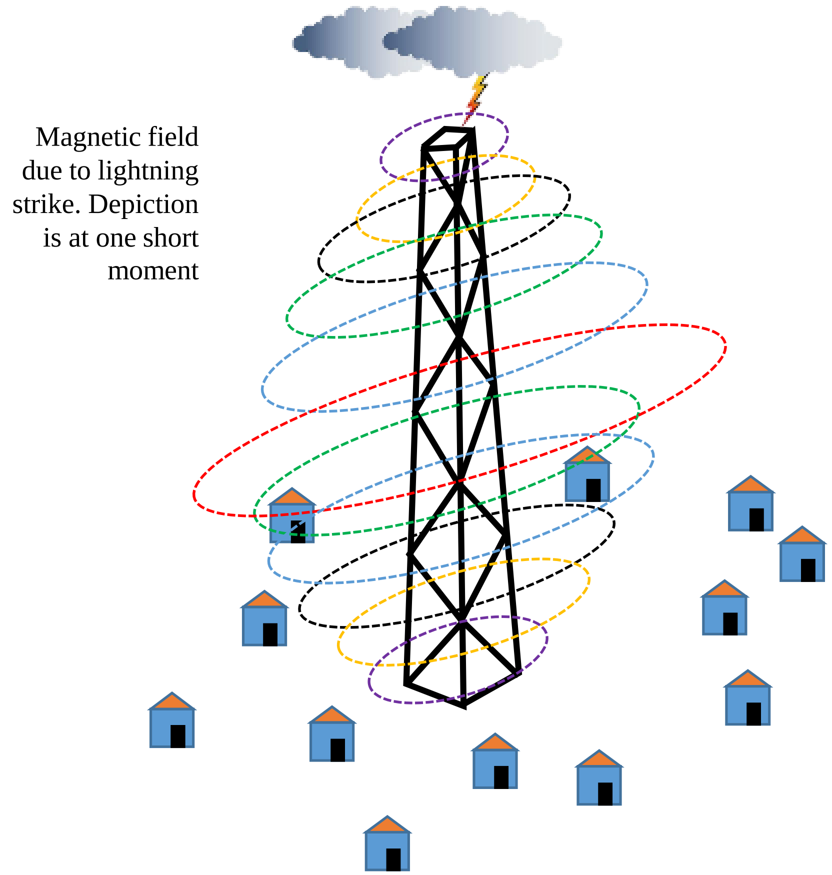
Magnetic Effects

- In the case of very near vicinity to the telecommunication tower, the rapid rise and fall of magnetic field caused by lightning can cut through electrical wires and result in electrical surges entering nearby facilities.



Solution to minimise effects from Magnetic Fields

- There is no solution available to mitigate this effect if the nearby dwellings or facilities are extremely close
- Luckily this effect decays very rapidly with respect to distance as the magnetic strength is inversely proportional to distance^2



Ground Potential Rise, Step & Voltages from Nearby HV and EHV Transformers and Power Lines

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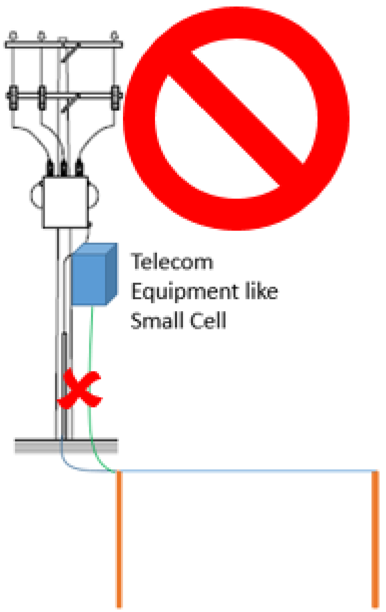
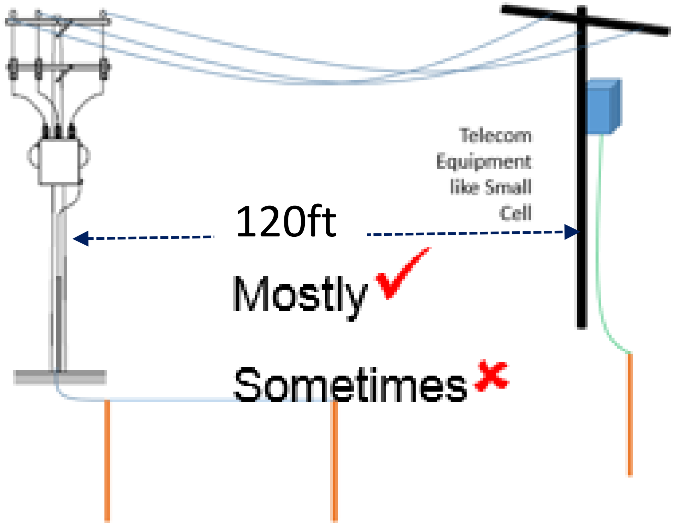
The potential problem

- Where the telecom ground electrode or the AC protective earth electrode of the telecommunication facilities is inadvertently located in high GPR zone close to an electrical substation or HV transformer, large and sometime prolonged electrical currents from power system faults can migrate across to the telecommunications service earth electrode and get to the ground via unwanted paths. This can be a potential public hazard, a fire risk or a risk to electrical damage to equipment.

EPR Near telecommunication equipment like small cells are installed on a power utility pole

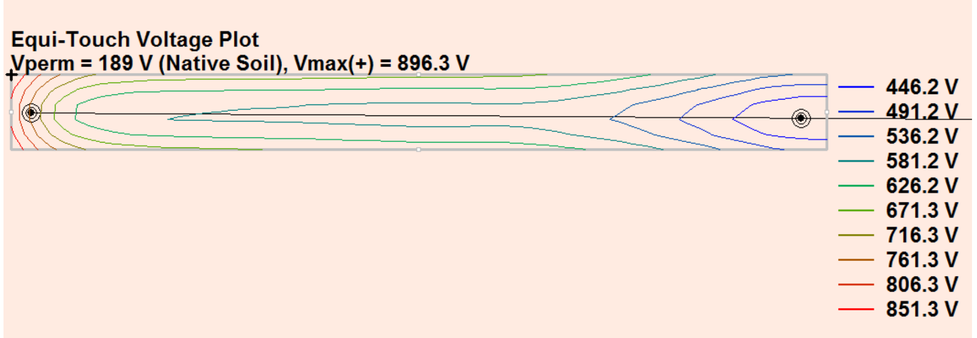


NOT RECOMMENDED. VOLTAGES DURING POWER SYSTEM FAULT WILL TRANSFER DIRECTLY TO TELECOM EARTH

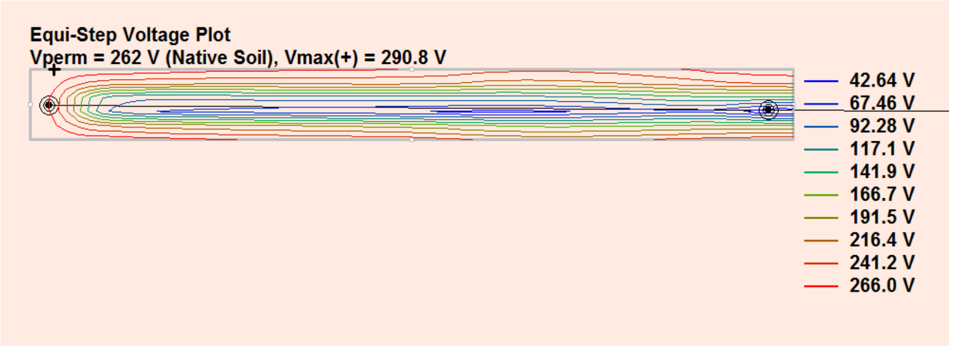


May get EPR from near pole

The modelling, the injected fault current at the transformer is 0.5kA for 0.5 seconds duration. The assumed soil resistivity for this modelling is 100ohm-m. The permissible touch and step voltages are shown below in the screen print from the software. It can be seen, the touch and step voltages can exceed the permissible values.



Resulting touch voltages around the transformer grounding



Resulting step voltages around the transformer

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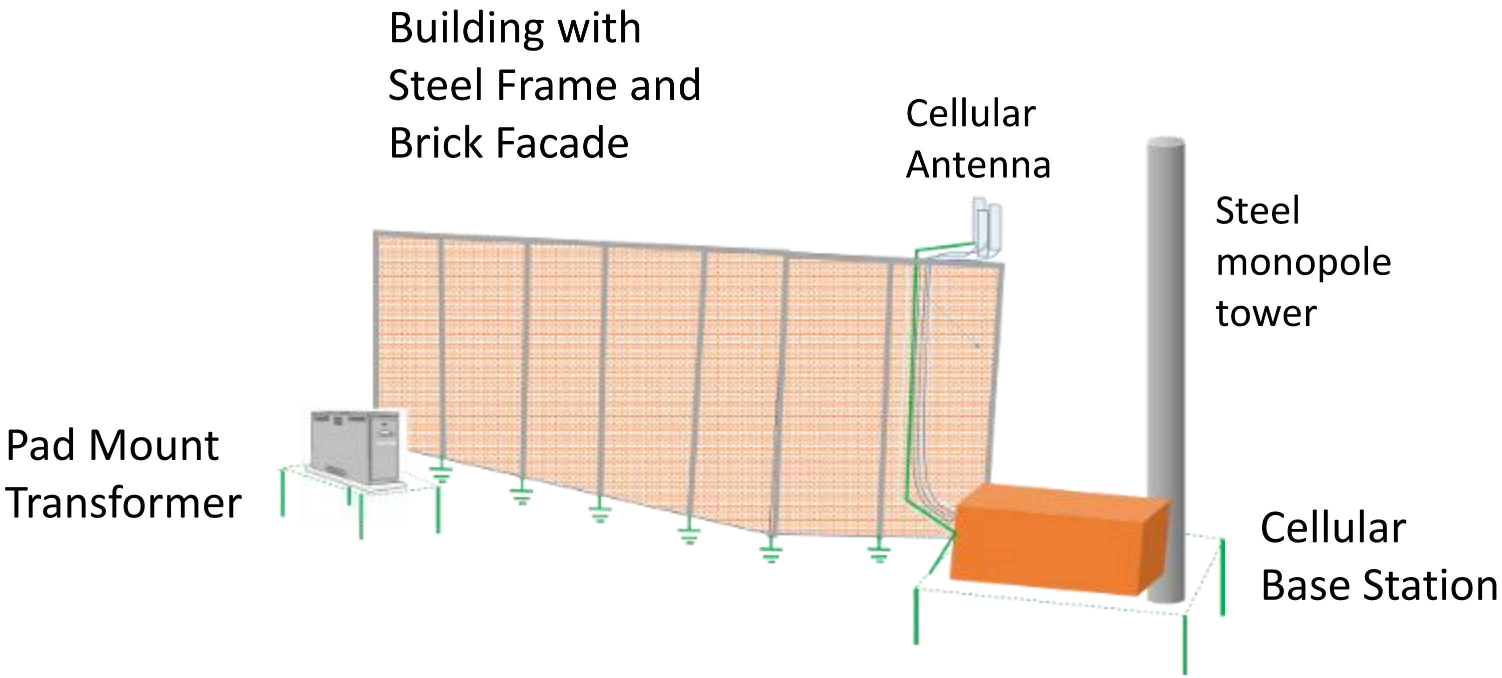
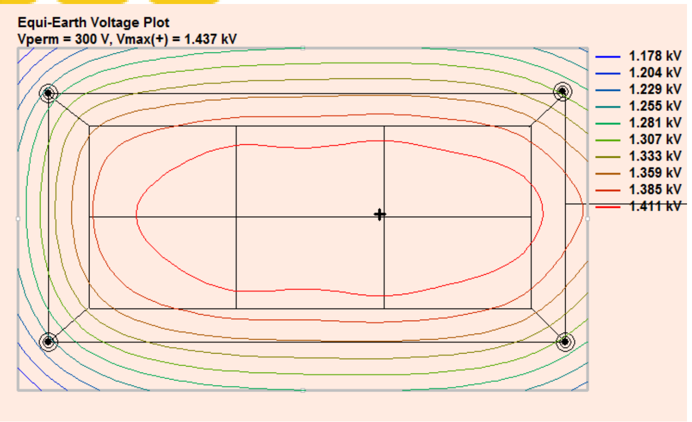
Transferred Voltage

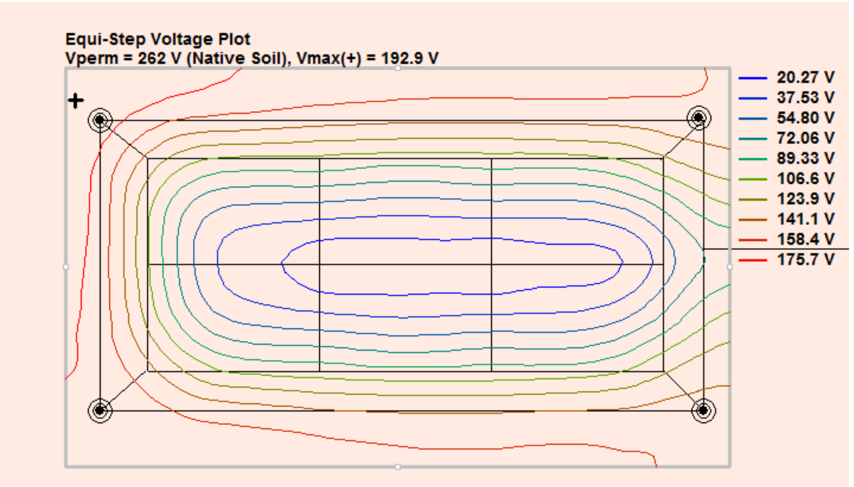
- There may be sufficient distance between the pad-mounted transformer and the radio site for a dangerous EPR situation not to exist. However, the presence of the steel frame building that is inherently earthed has the potential to transfer voltage from the transformer to the earth system of the radio site.
- Care should be taken not only to allow adequate separation distance to minimise EPR but also transferred voltages.



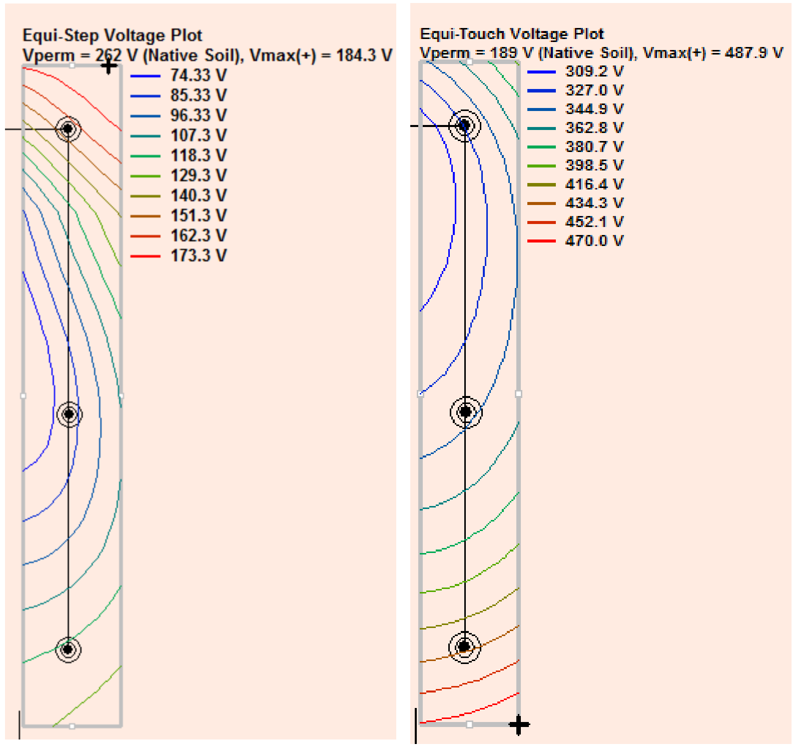
EPR - STREET CABINETS NEAR PAD MOUNT TRANSFORMERS



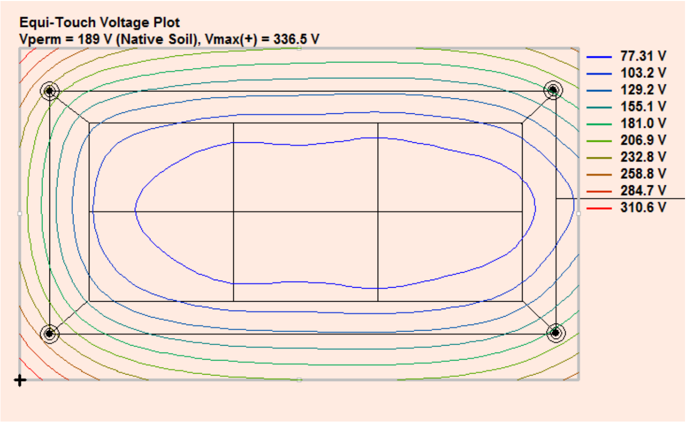
Resulting EPR around the transformer



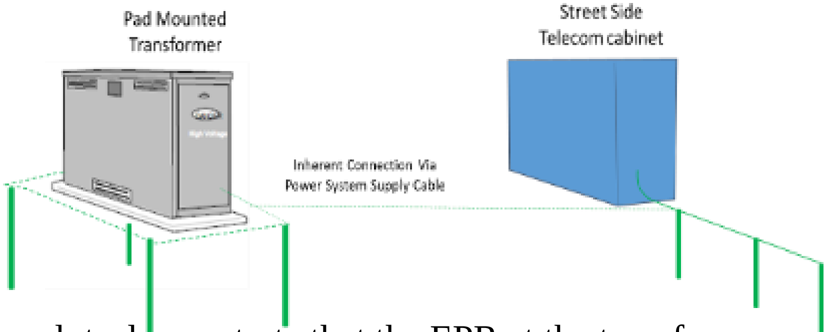
Resulting step voltage around the transformer



Resulting touch step voltages at the telecom ground electrode

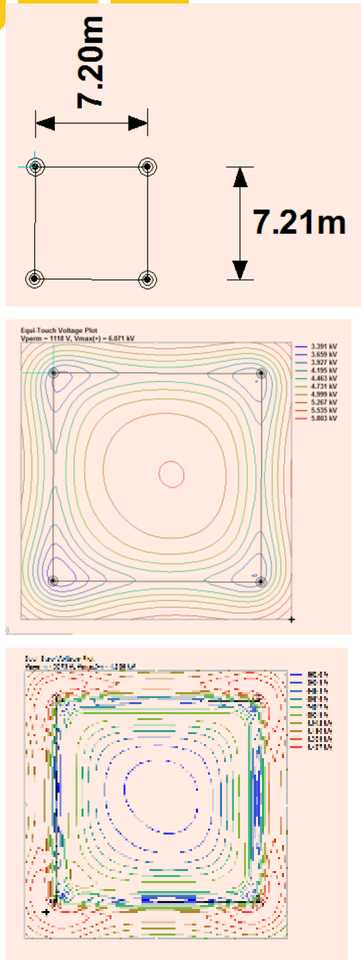


Resulting touch voltage around the transformer

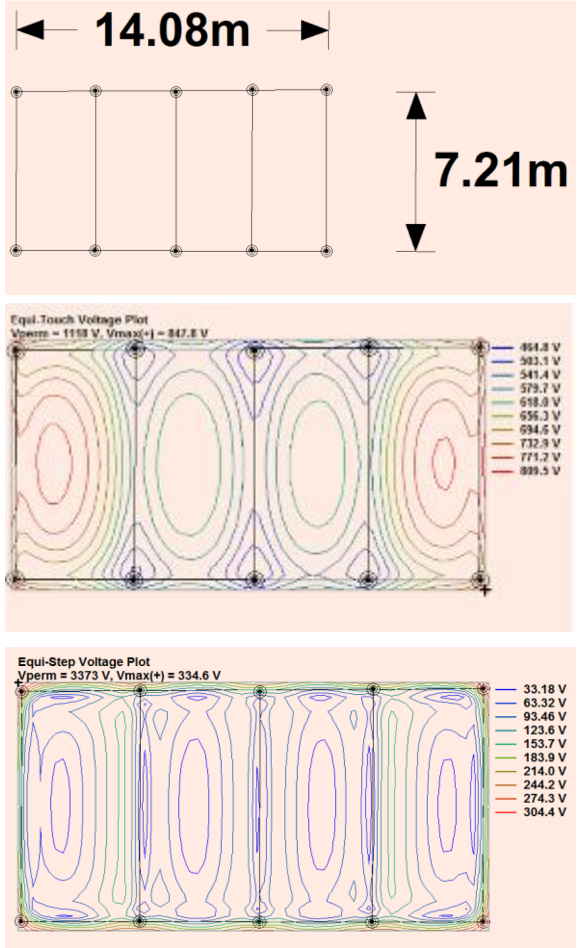


The plots demonstrate that the EPR at the transformer can appear at the earthing system of the telecom street cabinet. Within this model a fault current of 0.5kA for 0.5seconds is injected at the transformer. The assumed soil resistivity is 100 Ohm-m.

EPR NEAR EHV TOWERS

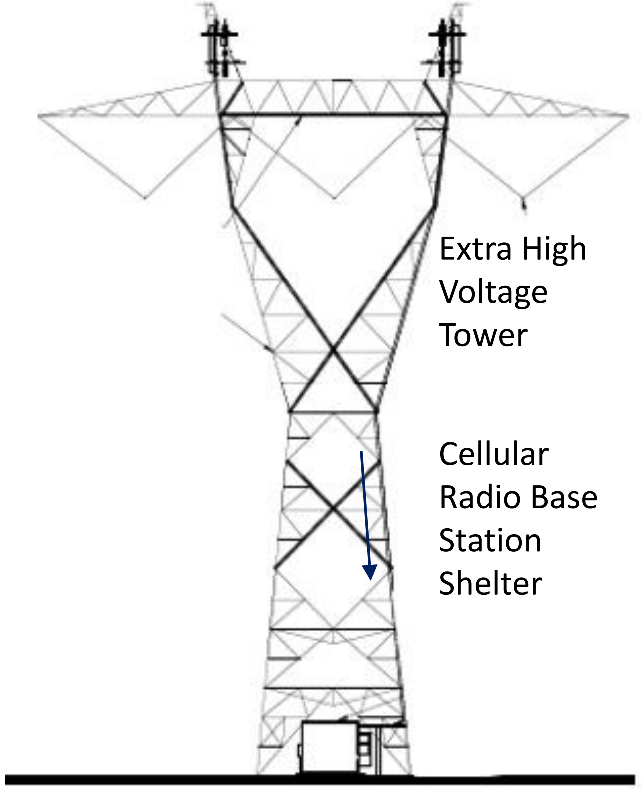


Step & Touch Voltages

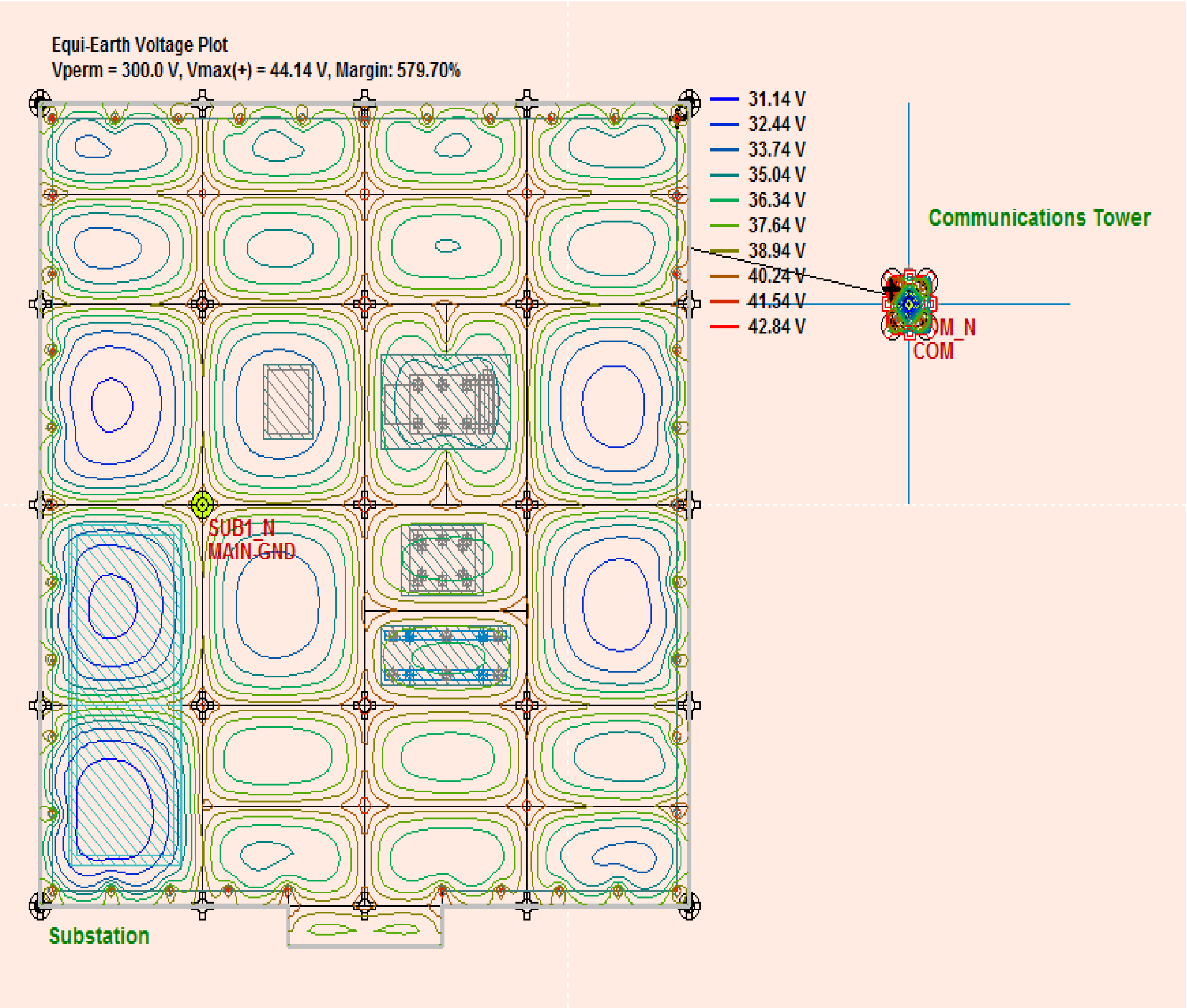


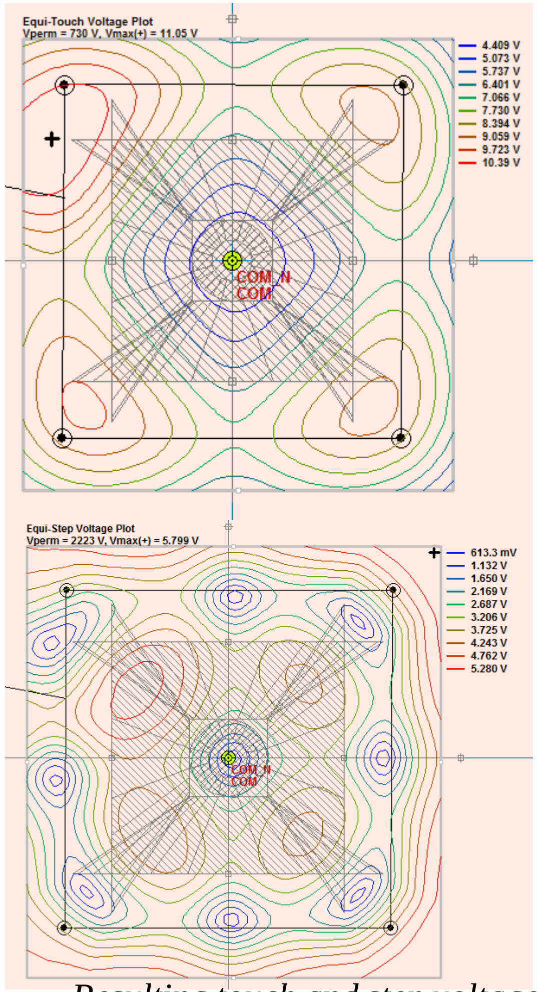
Step & Touch Voltages

- Phase to ground faults on EHV transmission towers are extremely rare.
- So while it may seem that there is risks associated with having a telecom shelter underneath a EHV tower this risk is small
- Fault current duration also are expected to be short
- The solution to improve this situation was to redesign the ground electrode system so it had more horizontal conductors in the middle and the size of the earth grid was increased and the grid size increased
- We have demonstrated in the modelling below that at a fault current of 17kA of 100ms duration will cause higher than acceptable around the telecom equipment if the standard design is applied. Soil resistivity at this site was 50 ohm-m.



Step & Touch Voltages – Tower Near Zone Sub-Station





Resulting touch and step voltages around telecom tower

- The final scenario that we will discuss here is whereby a telecommunications shelter is placed next to a large EHV switchyard.
- Although the telecom tower is at some distance outside of the substation zone, touch and step voltages will exist around the telecom tower.
- Careful design in necessary in this case to ensure that the touch and step voltages are within the permissible range.

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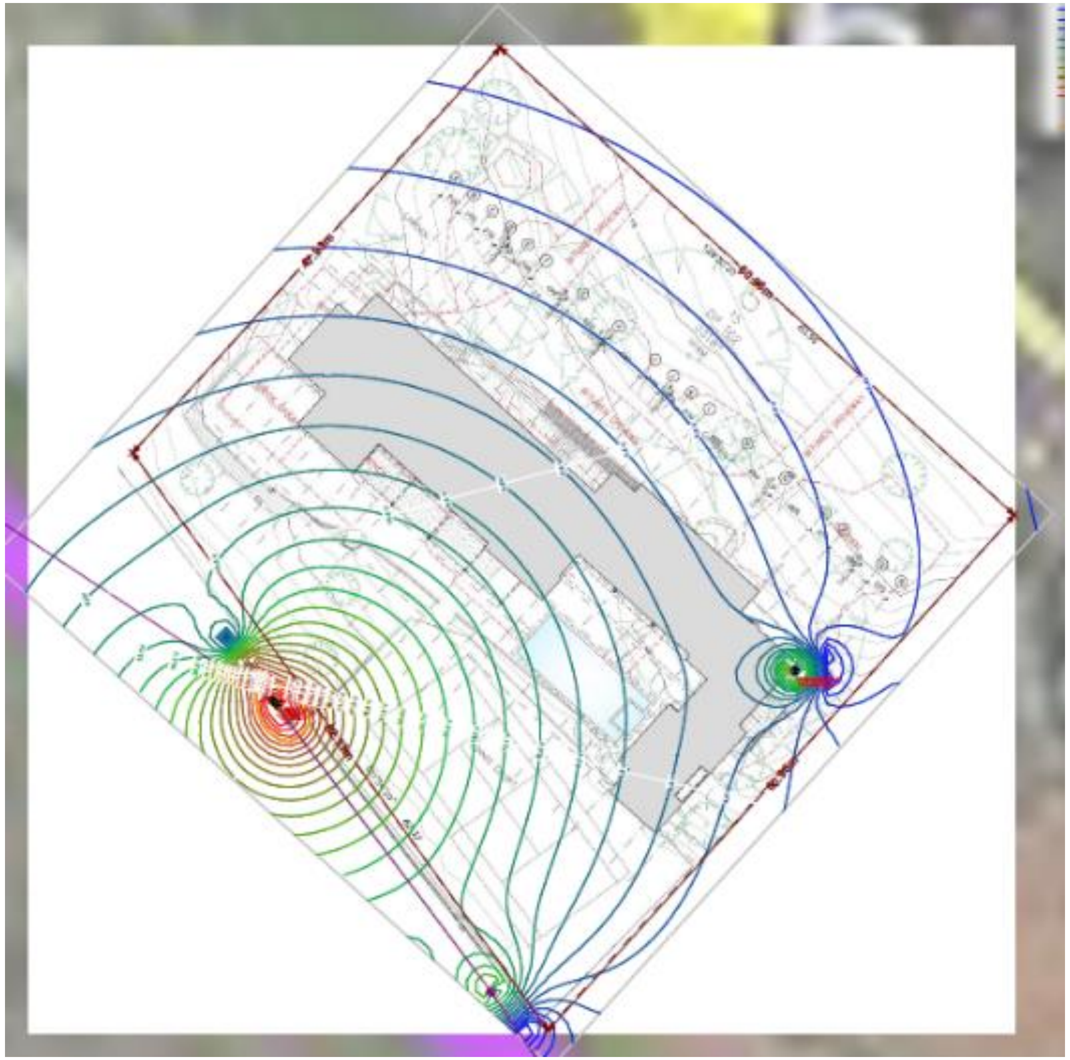
Holistic Modelling

- The modelling examples above have been carried out at the localized level assuming a fault current and duration close to the facility.
- To get a much clearer idea of the resulting step and touch voltages near a local substations, a more complete fault current analysis and modelling of the whole or larger part of the power system needs to be done.
- While this the correct and desirable method of modelling the earthing system of a network, often in real life one may not have access to the whole power system layout and the parameters for fault setting in the power system. In this cases localizes modelling will need to be used.



Example of holistic modelling of power system earthing

Conclusion

- The purpose of this presentation is to discuss and draw attention to GPR and other effects of lightning to and near a telecommunications tower in a densely populated area and GPR effects of utility transformers and sub-stations close to telecommunications facilities.
- While some examples are given, the scope of telecom facilities covered will extend to telecommunications equipment, distributors and other connecting hardware, grounded surge suppression devices, telecommunications electrodes , pits, access holes, or cable joints that are associated with any cable that contains electrically conductive elements, should not be placed in a location where the EPR may exceed a certain value under power system fault conditions. Modelling techniques to carry out site specific design exists and can be used.