Content

- Importance on low ground impedance

- Transmission line model for ground impedance

- How to practically implement low impedance grounding at telecom site

Impedance Discussion

- In telecommunications, the two important criteria in the design of the grounding system, are its performance at higher frequencies and its ability to handle lightning currents.

- Other than for safety, the key reason for telecommunications grounding is the control of lightning surges & transients and noise, which are all high frequency events.

- Hence it is the impedance rather than just resistance alone, that needs to be considered to determine the performance of an grounding system.

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Impedance Discussion

- For the purpose of demonstrating the effect of frequency, the closest available model that one can use for a long horizontally buried ground wire is the transmission line model. The characteristic impedance of two wires, like transmission line running parallel can be modelled by the equation below. If one was to extend this model to a long buried ground wire, whereby the ground is be considered the return path as shown
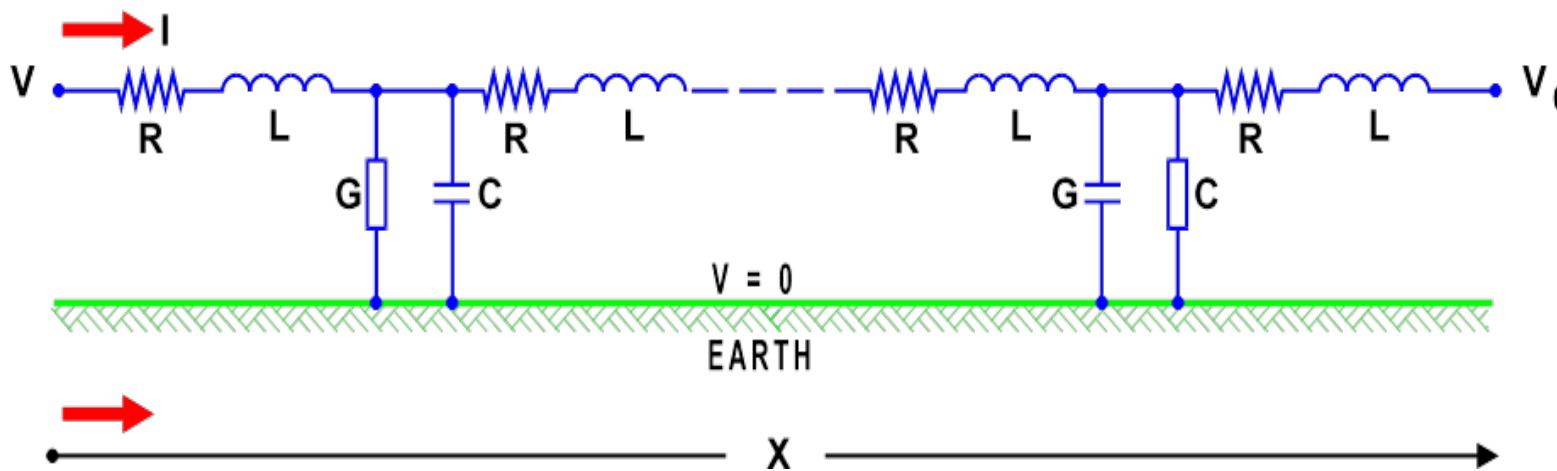
$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

where

     is the resistance per unit length

     is the inductance per unit length,

     is the conductance of the dielectric per unit length,

C is the capacitance per unit length,

     is the imaginary unit, and

     is the angular frequency = 2πf, where f is the frequency

Impedance Discussion

- It can be seen from above that at higher frequencies, the inductance and capacitance will be the dominant term because the reactive impedance or the imaginary unit gets multiplied by the frequency value, which will be a large number.

- The design approach in lowering the impedance at high frequencies will be to:

  - Increase the capacitance, C

  - Decrease the inductance, L

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

Practical Hints on Reducing Impedance

- The capacitance is largely a factor for how the two conductors are laid with respect to each other, in the case the ground conductor, how it is laid with respect to the ground. The metal used or the material itself will not affect this.

- It can be postulated that if the conductor is a tape with much wider diameter than a wire, then the capacitive coupling to ground will increase due to the larger surface area of contact and inductance will reduce

- Similarly if a mesh of any metal is used within soil, within concrete or within Ground Enhancement Material or GEM it will provide a large capacitance coupling to ground.

- Capacitive coupling can also be enhanced by the use of crows foot design.
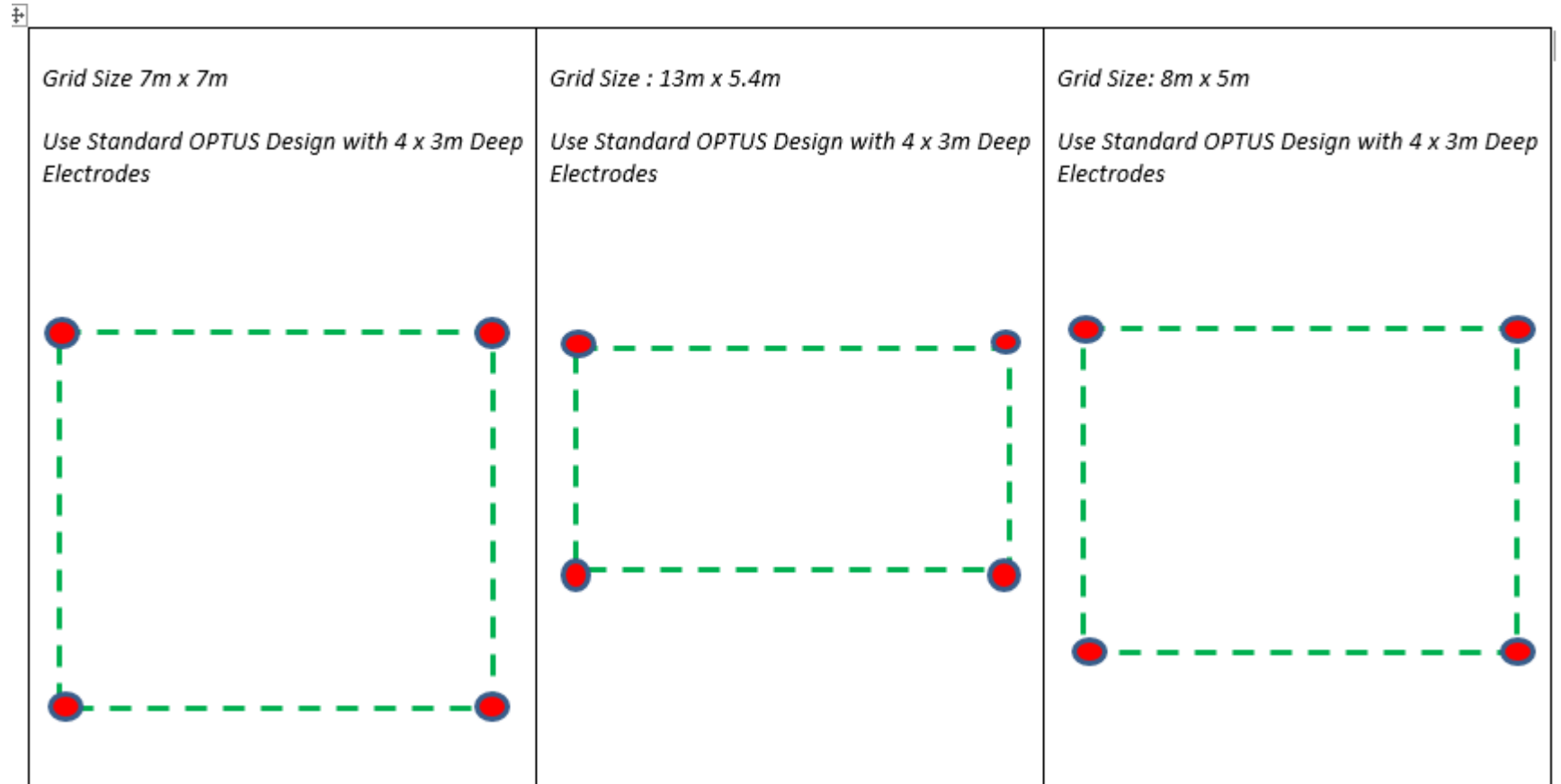
Example of How This Concept Can be Used

- We are looking at a case study whereby the telecommunications carrier had by legislation required to have 5 ohm ground resistance

- They were allowed to relax the resistance values to 12.5 ohms of 5 ohms could not be achieved

- In some instance 12.5 ohms was also a challenge but it could be accepted with carrier acknowledging that performance against noise & lightning control could be degraded.

- The approach to design was to use varying designs as soil resistivity value degraded at various site

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Scenario 1

- **Soil Resistivity** <= 50 ohm-m measured at spacing a = 3m

- **Target Resistance** : 5 ohms

Grid Size 7m x 7m

Use Standard OPTUS Design with 4 x 3m Deep Electrodes

Grid Size : 13m x 5.4m

Use Standard OPTUS Design with 4 x 3m Deep Electrodes

Grid Size: 8m x 5m

Use Standard OPTUS Design with 4 x 3m Deep Electrodes

Scenario 2

Soil Resistivity 50-100 ohm-m measured at spacing a = 6m

Target Resistance : 5 ohms

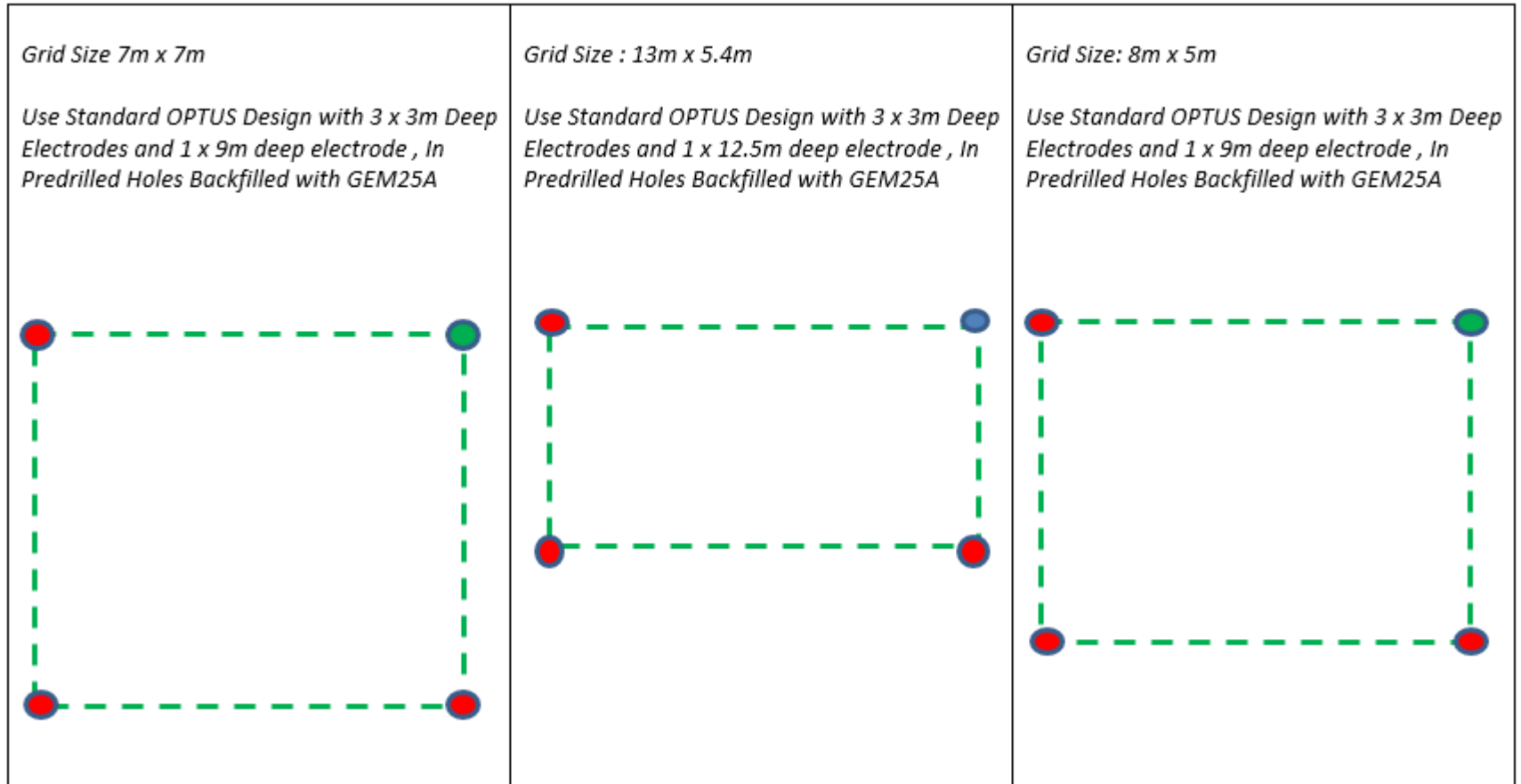| Grid Size 7m x 7m	Grid Size : 13m x 5.4m	Grid Size: 8m x 5m
Use Standard OPTUS Design with 4 x 6m Deep Electrodes	Use Standard OPTUS Design with 4 x 6m Deep Electrodes	Use Standard OPTUS Design with 4 x 6m Deep Electrodes

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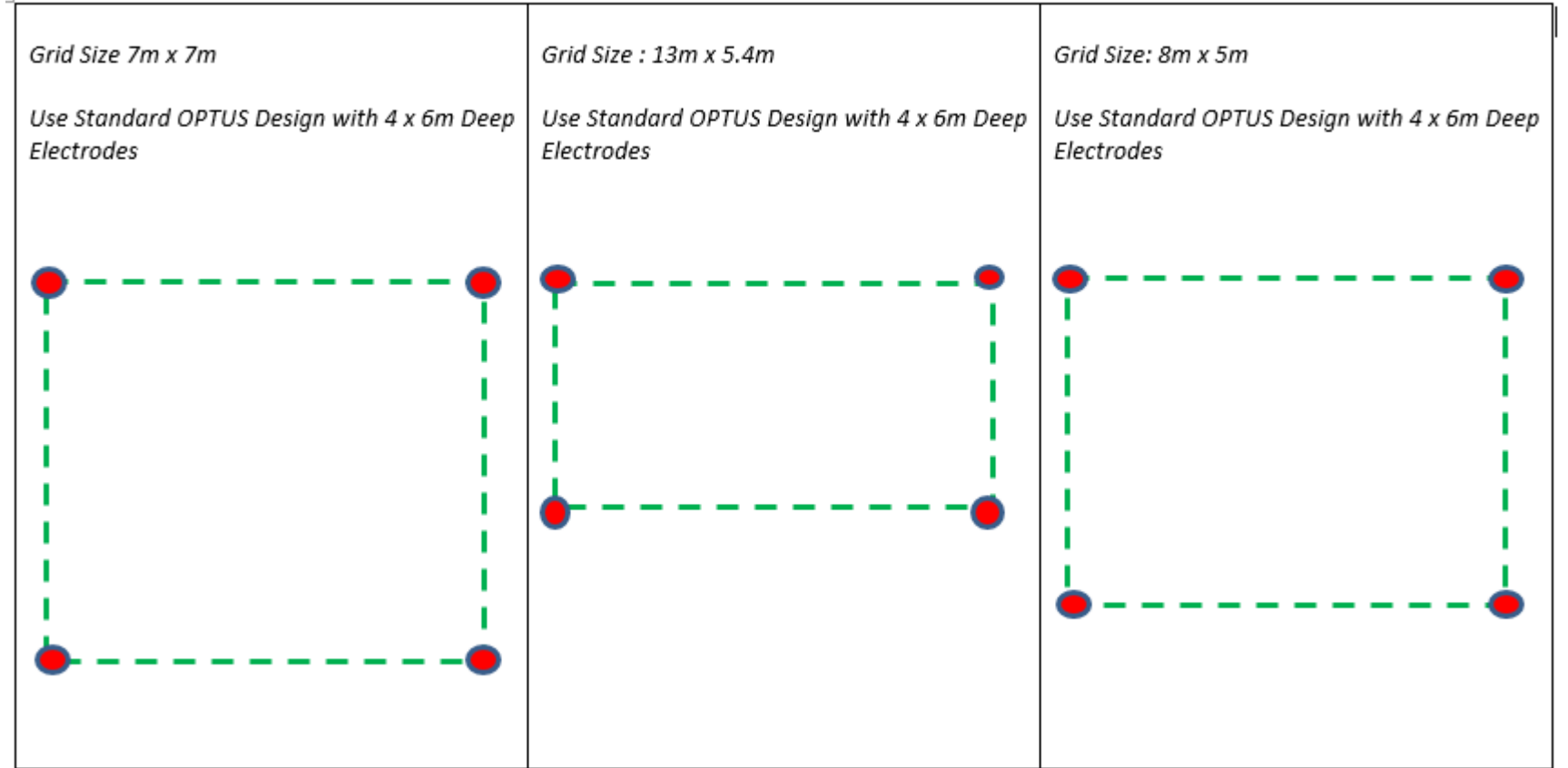
Scenario 3

- **Soil Resistivity** 100-150 ohm-m measured at spacing a = 6m

- **Target Resistance :** 5-8 ohms

Grid Size 7m x 7m

Use Standard OPTUS Design with 4 x 6m Deep Electrodes , In Predrilled Holes Backfilled with GEM25A

Grid Size : 13m x 5.4m

Use Standard OPTUS Design with 4 x 6m Deep Electrodes , In Predrilled Holes Backfilled with GEM25A

Grid Size: 8m x 5m

Use Standard OPTUS Design with 4 x 6m Deep Electrodes , In Predrilled Holes Backfilled with ERICO GEM 25A

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Scenario 4

- **Soil Resistivity** 150-300 ohm-m measured at spacing a = 9m

- **Target Resistance :** 12.5 ohms

Grid Size 7m x 7m

Use Standard OPTUS Design with 3 x 3m Deep Electrodes and 1 x 9m deep electrode , In Predrilled Holes Backfilled with GEM25A

Grid Size : 13m x 5.4m

Use Standard OPTUS Design with 3 x 3m Deep Electrodes and 1 x 12.5m deep electrode , In Predrilled Holes Backfilled with GEM25A

Grid Size: 8m x 5m

Use Standard OPTUS Design with 3 x 3m Deep Electrodes and 1 x 9m deep electrode , In Predrilled Holes Backfilled with GEM25A

SCENARIO 5 – Low Impedance Design

- **Soil Resistivity** >300 ohm-m measured at spacing a = 12m

- **Target Resistance :** NIL. Calculate resistance at, 300ohm-m, 350 ohm-m, 400ohm-m, 450 ohm-m, 500 ohm-m, 1000ohm-m, 1500 ohm-m
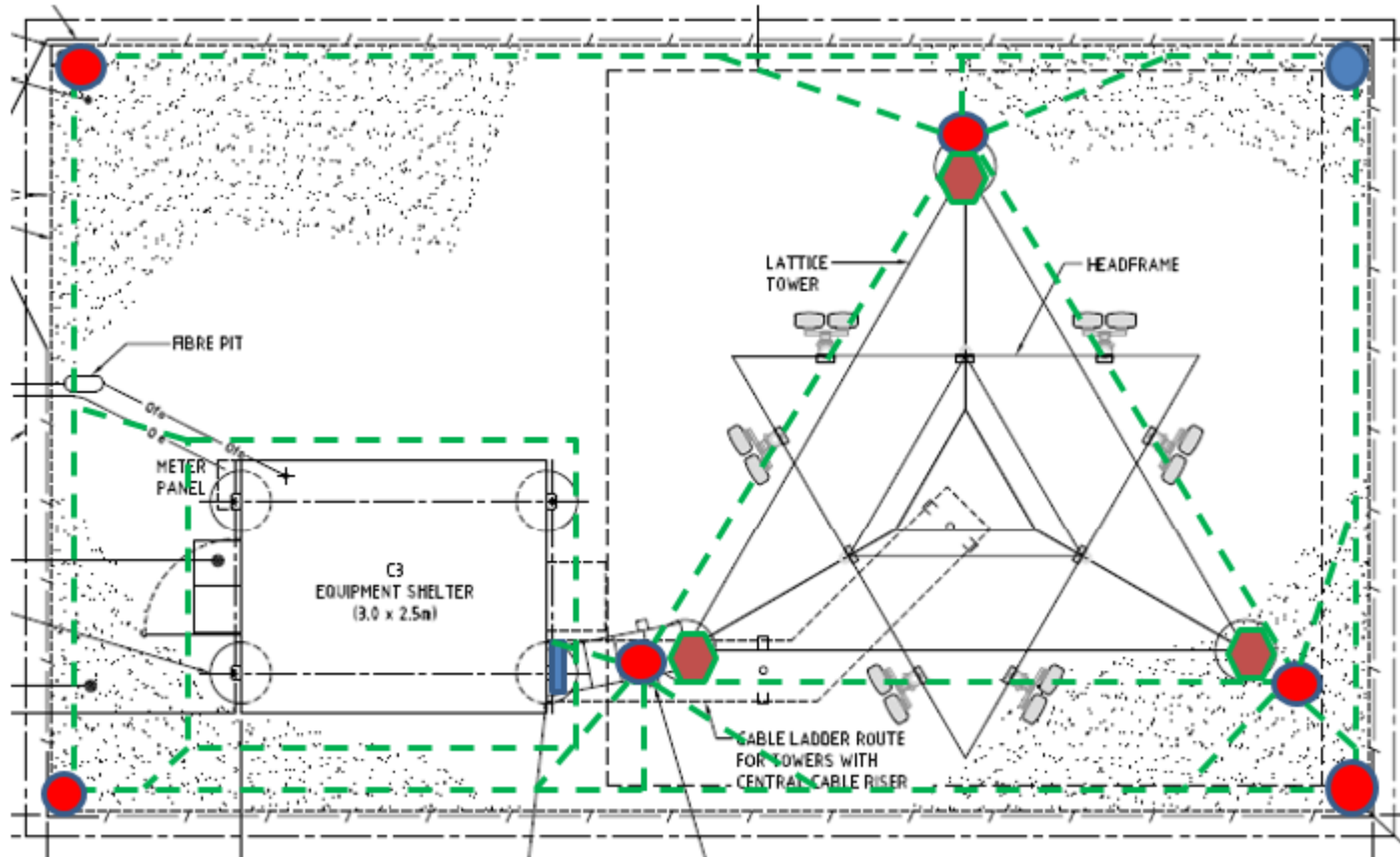
Crows Feet: Three way radials to reduce ground voltage by splitting current and increasing capacitive coupling

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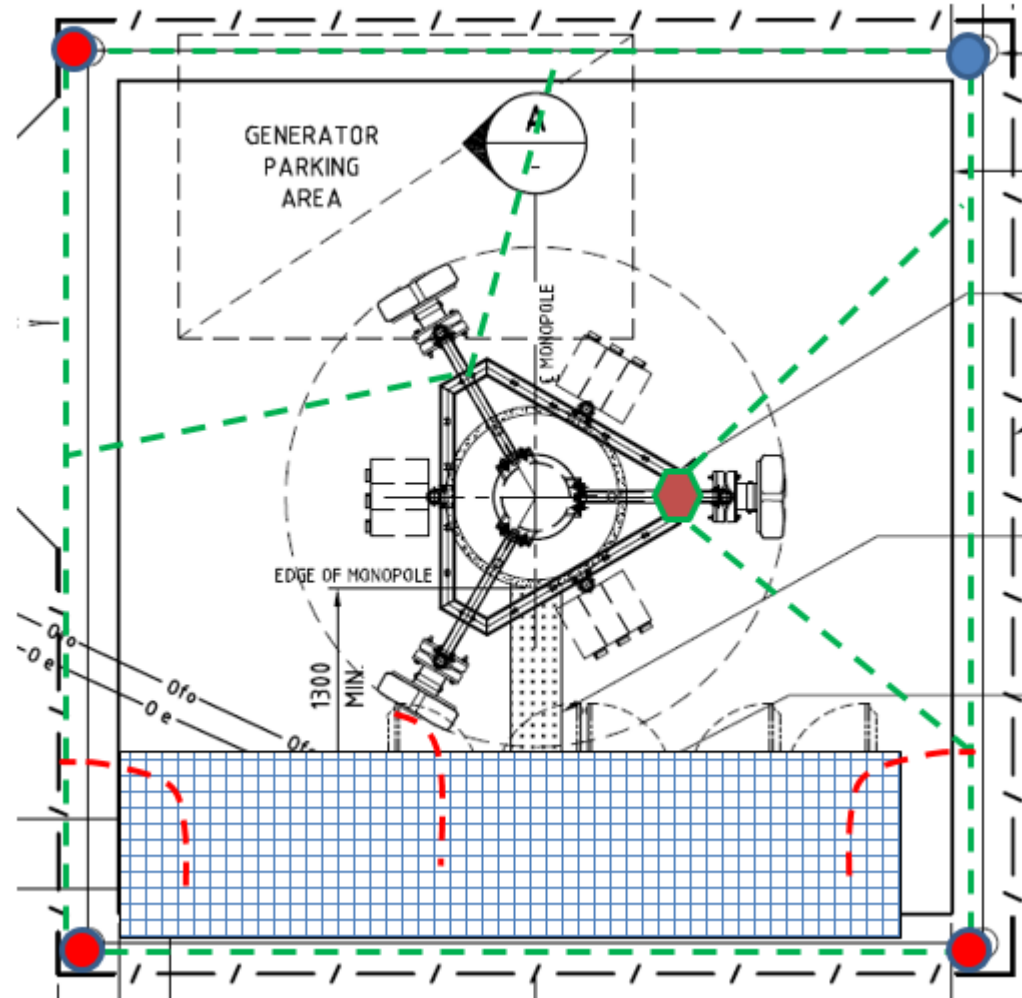
Crows Feet: TWO way radials to reduce ground voltage by splitting current and increasing capacitive coupling

Mesh: Beneath Equipment Cabinets for tight GPR control and high capacitive coupling
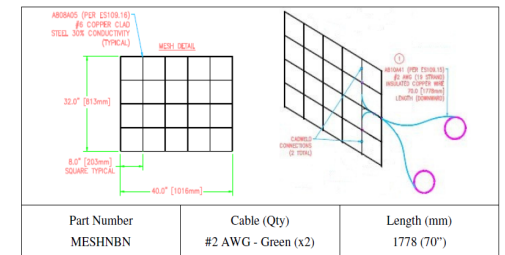
TESTING OF IMPEDANCE

- Resistance test is used as bench mark as that is relatively easy to test

- Impedance test equipment have appeared in the market but there is challenges in testing

  - The results can depend on how test leads are laid out

  - No consensus on what is a good impedance value

  - Impedance values done with different brands of equipment will vary

- This does not stop us from doing an intuitive low impedance design

  - Remember we talking about sites where target resistance cannot be achieved in any case.

THANK YOU