YOUNG PROFESSIONALS SUSTAINABILITY IMBIZO 2018

Eskom

Cost effective methods to counter voltage collapse and stability problems

Presented by: Tumisang P Maphumulo (Lebo)
Date: 15 August 2018

Introduction

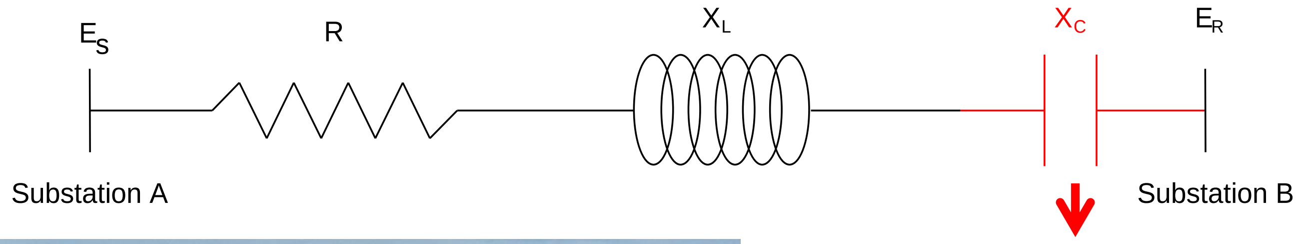
- The pursuit for cost effective, more reliable and efficient methods to counter voltage collapse and stability problems.

- Increase power transfer on new Main Transmission System (MTS) assets without using series compensation.

- Challenges that are faced with power lines are
  - High cost and low return
  - Servitude acquisition difficulties
  - Strict statutory requirements
  - Challenging environmental considerations

Series capacitor bank

Fixed Series Capacitor (FSC) bank is connected in series with an overhead transmission line AC, to increase the Power Transfer by compensating the inductive portion of the line.



Advantages of series capacitors

- Series capacitors
  - Self-regulating devices
  - Increase Power Transfer (MW) of a Transmission Line by reducing reactive power consumption
  - Improved Load Division on Parallel Circuits
  - Improves Voltage Regulation
  - Improves the system stability, reduces angular and voltage stability restrictions (limits)
- This is achieved by:
  - Reducing the line’s series inductive reactance (eelectrical length)

High Surge Impedance Loading (HSIL)

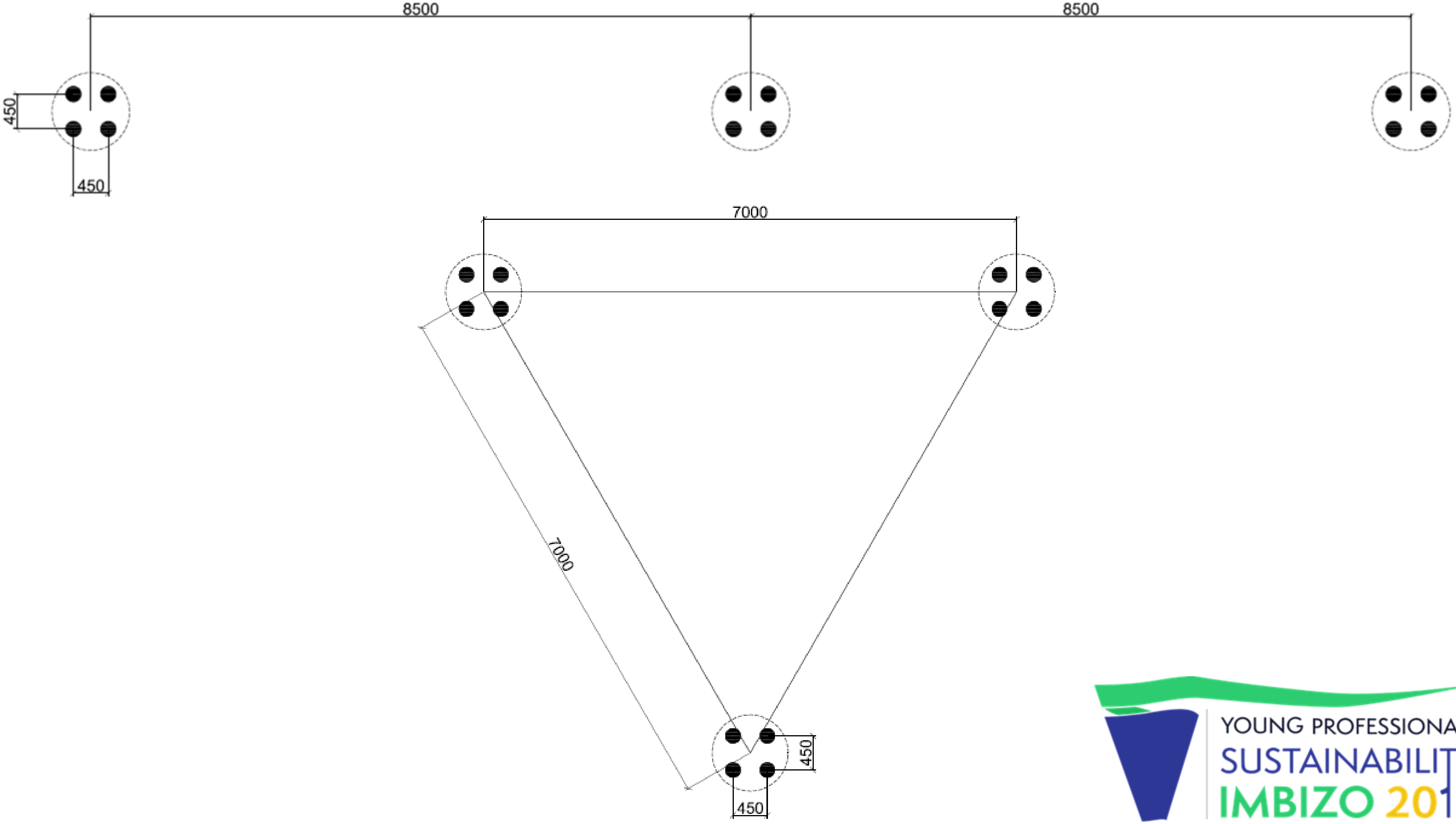
- High Surge Impedance Loading (HSIL) methods can
  - Increase SIL of long lines by:
    - ✓Decreases the series Inductive reactance
    - ✓Increase in the shunt capacitive reactance
  - Depending on the network, the SIL can be increased substantially enough to eradicate the need to install series capacitors on long transmission lines

HSIL methods

- Increasing the number of sub-conductors in the bundle
  - Reduces the current in each subconductor which reduces the flux linkage of each sub-conductor
- Bundle expansion
  - Reduces the flux linkage of each sub-conductor
- Phase compaction
  - Increases the flux cancellation
  - Reduces the flux linkage of the phase conductors
- Different conductors

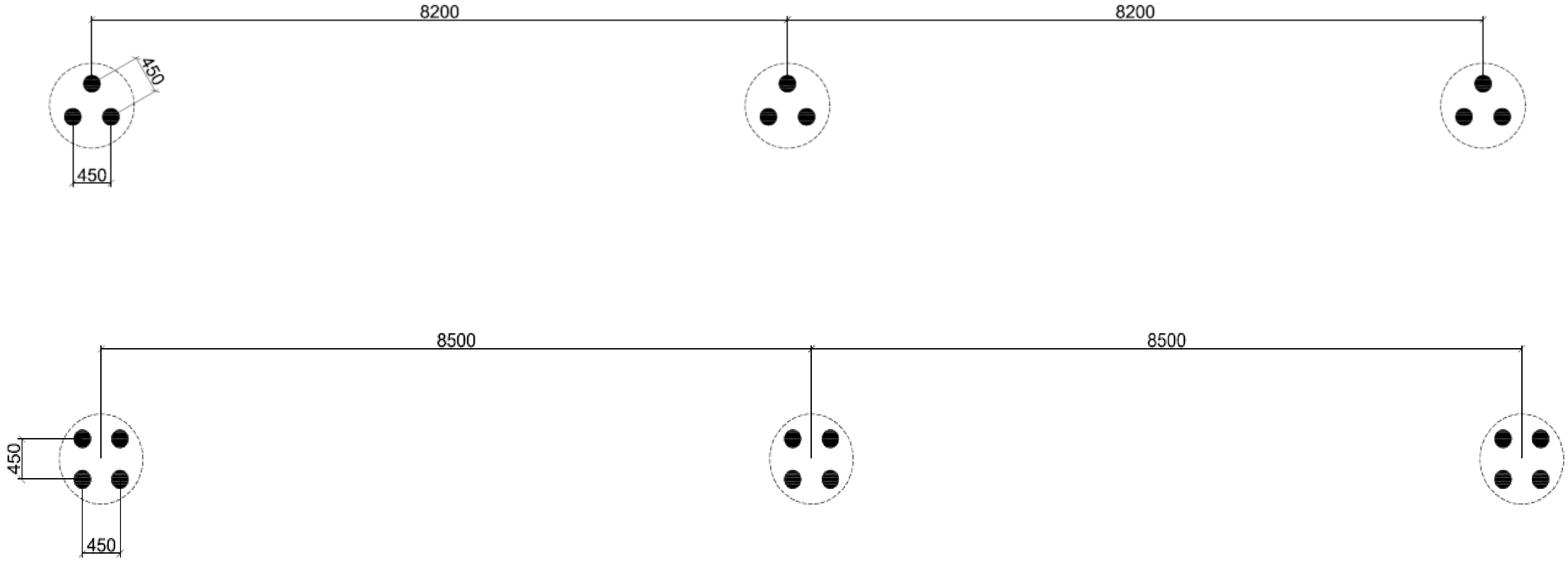
HSIL Techniques – Method 1

- Compacting the phases (perfect inverted delta)



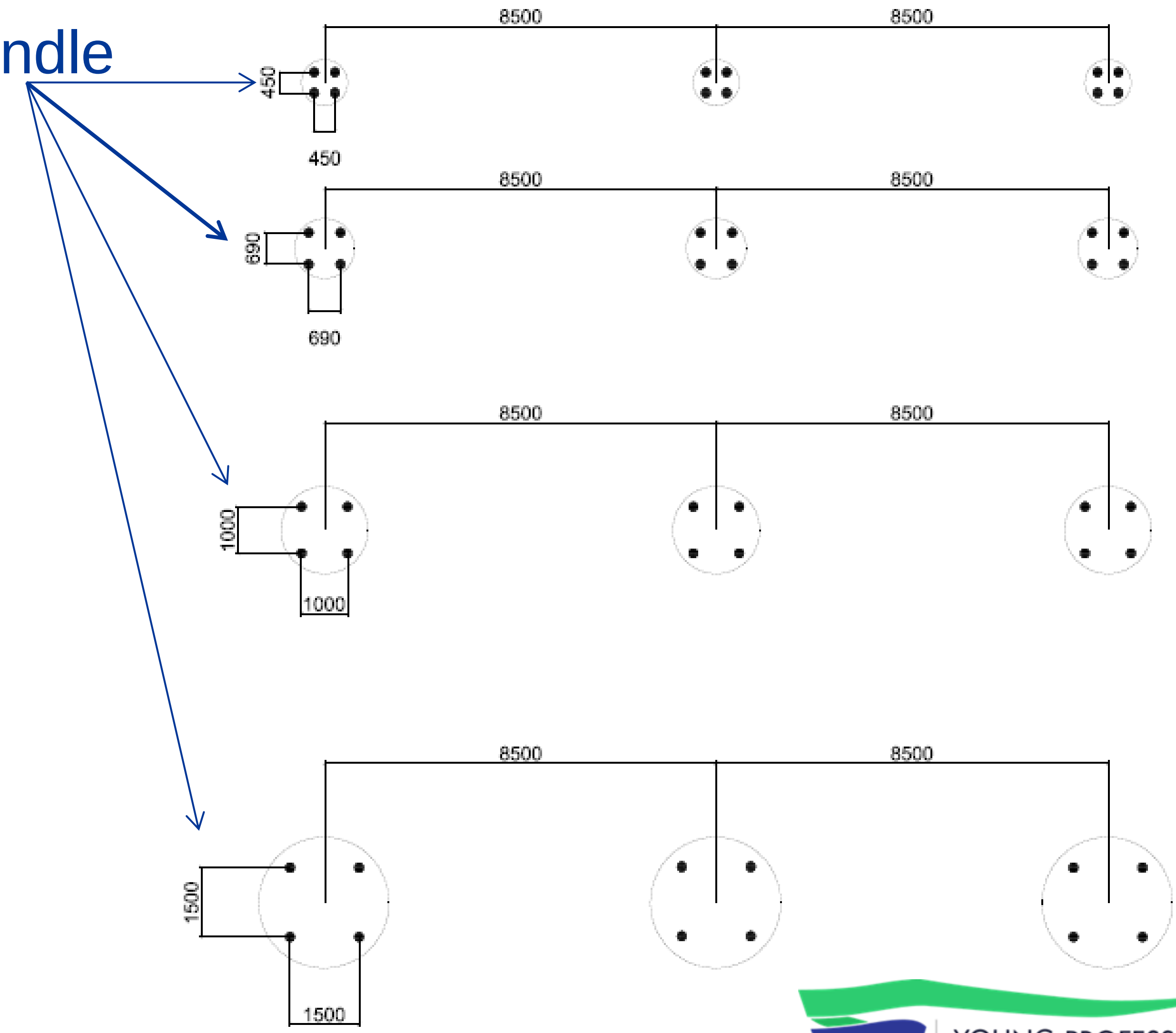
HSIL Techniques – Method 2

- Increasing the number of sub-conductors in the bundle

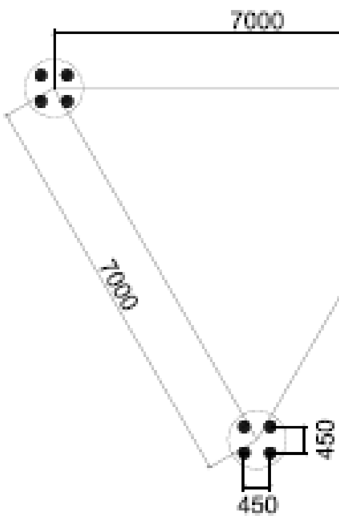


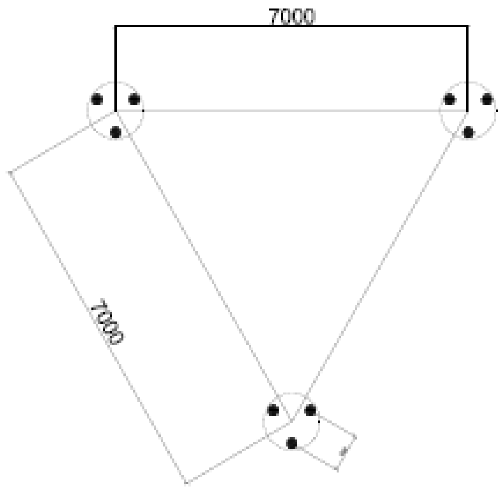
HSIL Techniques – Method 3

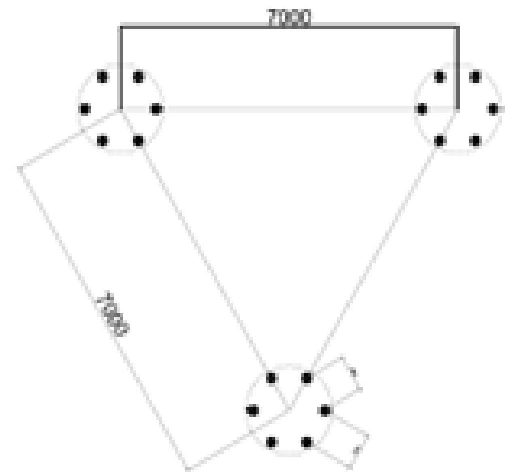
- Expanding the bundle

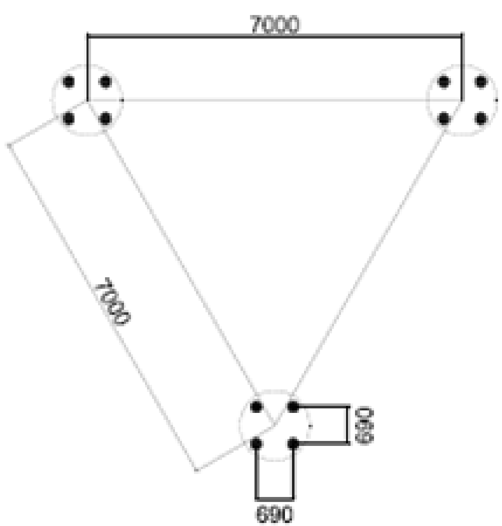


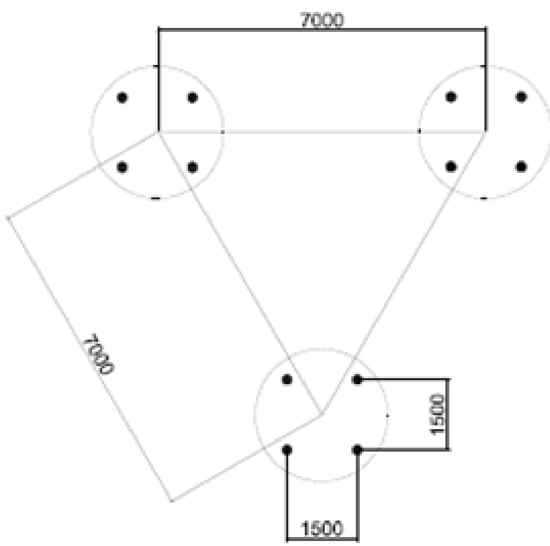
Varying the sub-conductor bundle size and conductor types



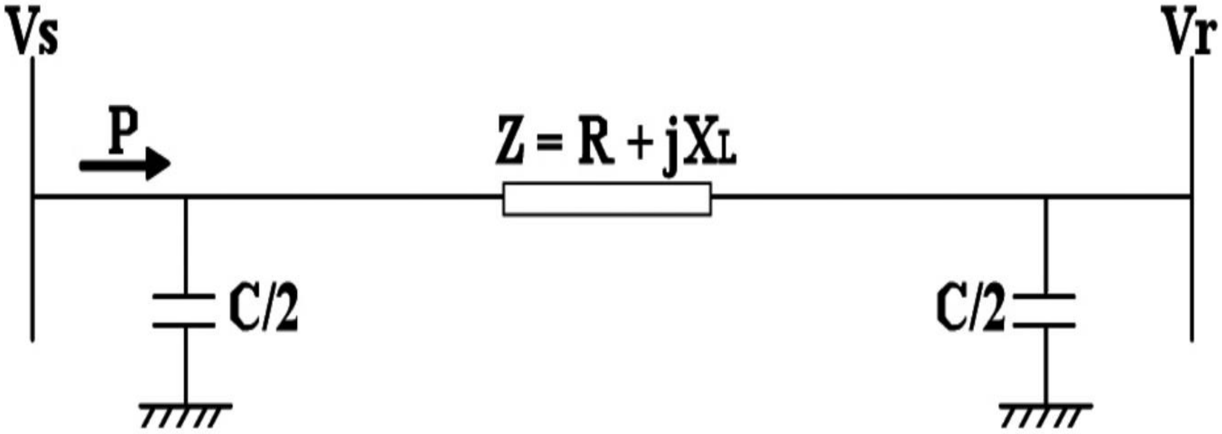








Line Model – PI Equivalent single-phase circuit



P = Transmitted power
Vs = Sending end voltage
Vr = Receiving end voltage
C = Shunt capacitance
X**L** = Series inductive reactance
R = Resistance
Zc = Series impedance

$$\mathrm{SIL} = \frac{V^2{}_{LL}}{Z_C} \quad (\mathrm{MW})$$

Where:

V_{LL} = Receiving end line voltage (kV)

Z_C = Surge Impedance of the line (Ω)

$$Z_C = \sqrt{\frac{L}{C}} \quad (\Omega)$$

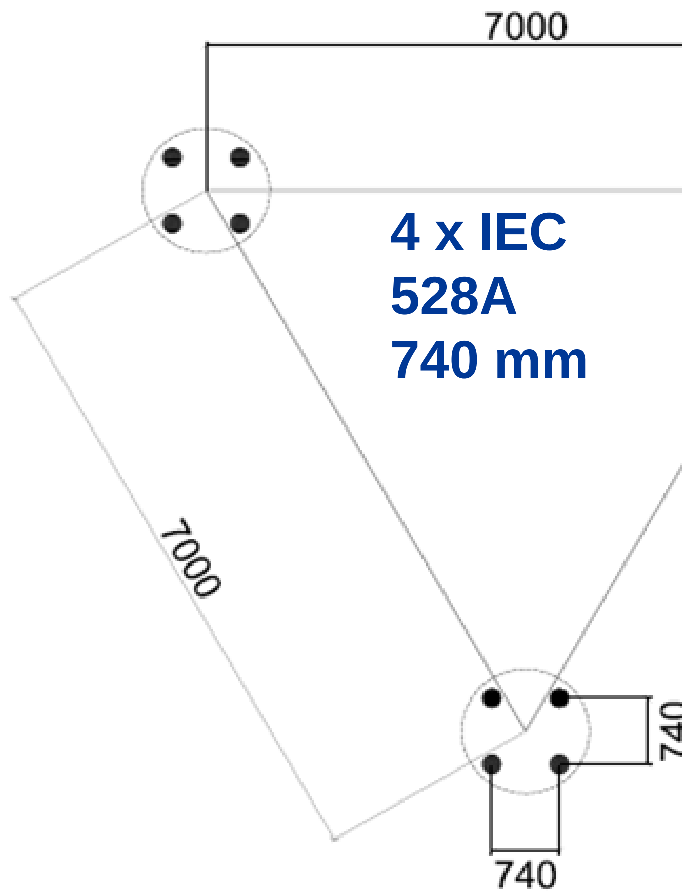
Where:

L = Series inductance per unit length (L/m)

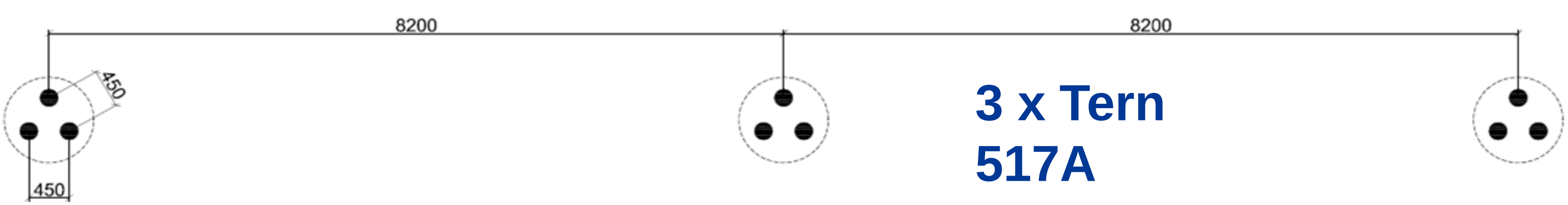
C = Shunt capacitance per unit length (F/m)

Improvements in line parameter and SIL

- R ↓ 30%
- X ↓ 29%
- B ↑ 42%
- SIL ↑ 36%



4 x IEC
528A
740 mm



3 x Tern
517A
450 mm

Natural Capacity / SIL

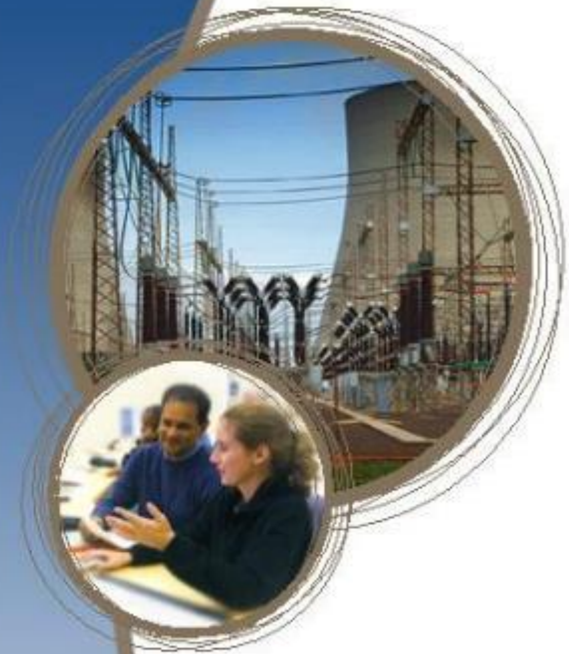
- The natural capacity (Mvar) is increased by a factor of 3.5 when compared to a conventional line.
  - Which translate to reactive power requirement that is 33% less than the conventional line.
- For the selected case in the Eskom network the series capacitor could have been eliminated
  - Estimated cost saving from GE is 8.5 million dollars (2017). The results also indicate that a 100 Mvar shunt line reactor is still required to prevent Ferranti effect voltages

Advantages of eliminating the series capacitors

- The advantages of removing the series capacitors;
  - Reduced capital cost.
  - Reduced maintenance cost.
  - Reduced environmental impact.
  - Improvement in system reliability since planned and unplanned outages for maintaining the capacitor is eliminated.
  - Simpler protection settings.

Recommendations

- Uprating of existing lines – expanded bundle (only hardware needs to be changes).
- New lines – combination of expanded bundle plus phase compaction (the bundle can be expanded as far as possible on the existing compact tower).
- New lines – phase compaction because the perfect inverted delta configuration eliminates the need to transpose the line to aid voltage unbalance because the voltage drop throughout the line is equal between the phases.



END