Single Wire Earth Return (SWER)

Meritec

ideas change everything

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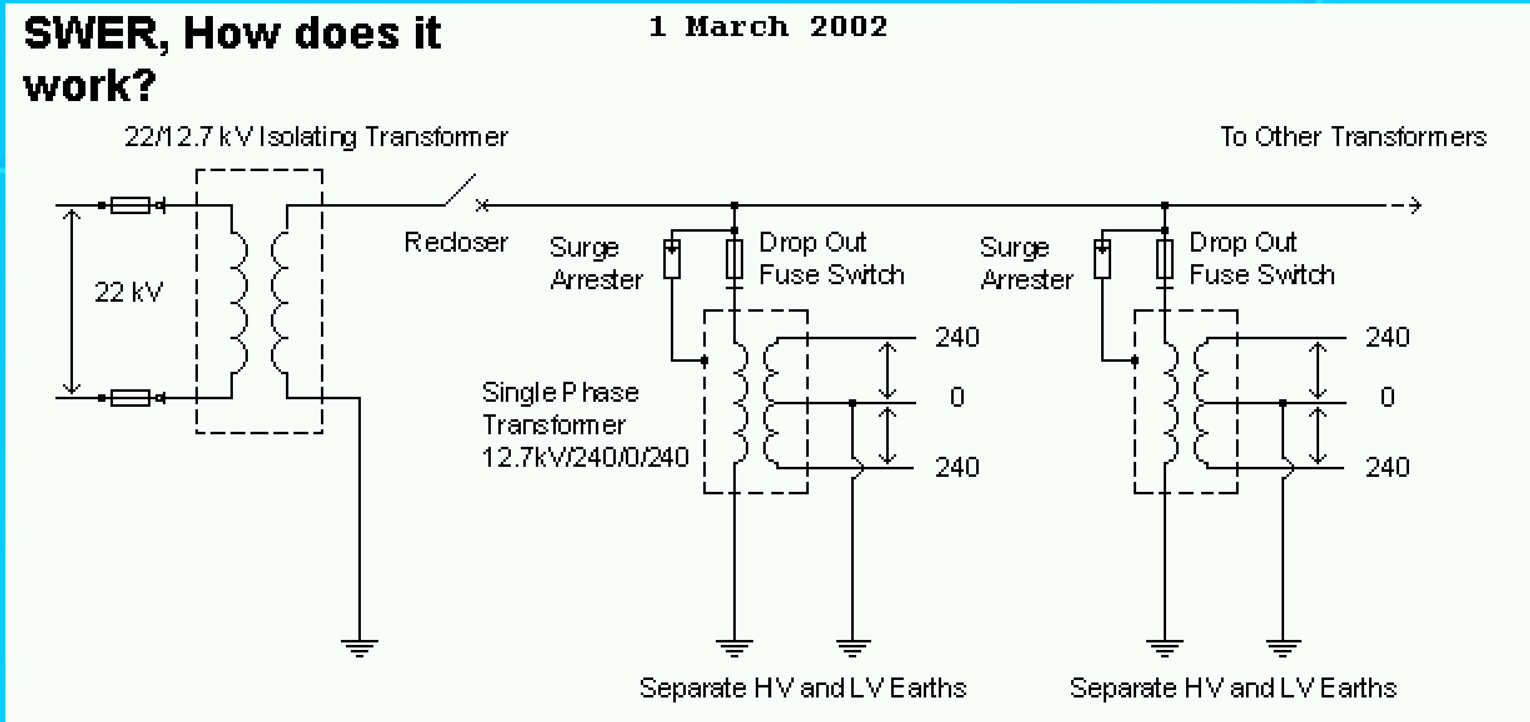
SWER

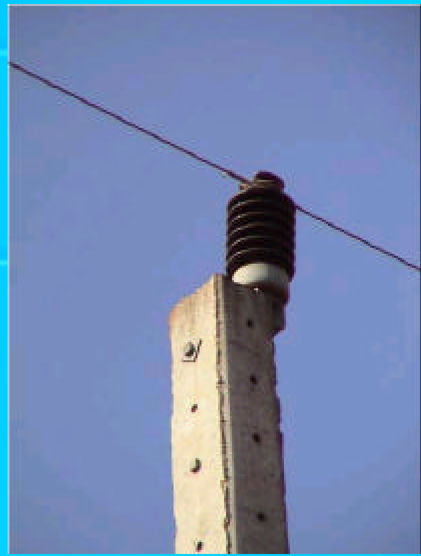
- Electricity distribution method using only one conductor with the return path through earth
- Successfully used in NZ, Australia, Canada, India, Brazil, Africa and Asia for sparsely populated areas
- Correctly applied, SWER provides an economic supply method for rural electrification and poverty reduction

SWER System



- Line to ground voltages typically 12.7kV or 19.1kV

SWER - Advantages



- Cost Reduction
  - One conductor, less pole top equipment
  - Long, hilltop to hilltop spans
  - Fewer switching and protection devices
- Design Simplicity
- Speed of Construction
- Reduced Maintenance costs
- Reduced bushfire hazard – avoid conductor clashing

SWER - Issues

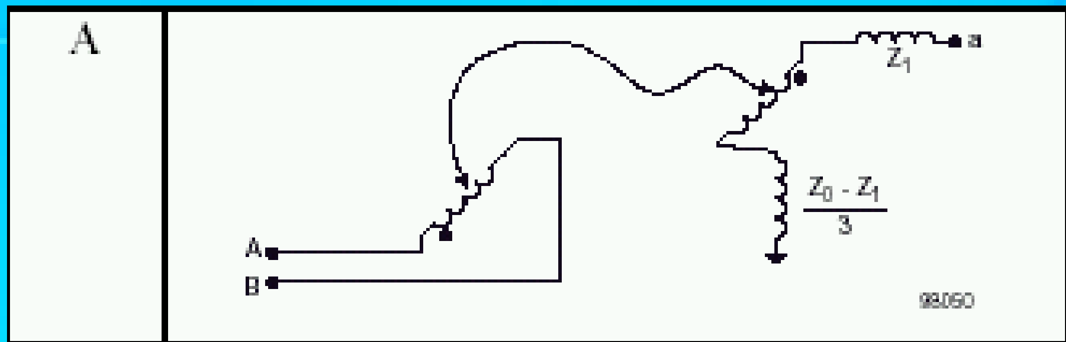
- Earthing must prevent dangerous step and touch potentials
- Telephone interference, similar to 2 wire single phase lines, worse than three-phase lines
- Load balance problems can erode efficiency of three-phase supply line
- Voltage control can be difficult
- Power quality can be compromised
- Load density limitations

Modelling SWER Isolating Transformer

- Voltage = 12.7 kV line to ground
- Rating = 200 kVA
- R = 1.6%
- X = 3.8%
- Earthing Resistance R_E = 1 ohm
- Therefore $I_{base} = \dfrac{200kVA}{12.7kV} = 15.7A$
- Voltage drop over R_E = 15.7A x 1 ohm
  = 15.7V
- $V\% = \dfrac{15.7\,V}{12.7kV} = 0.0012 = R_E$ (pu)

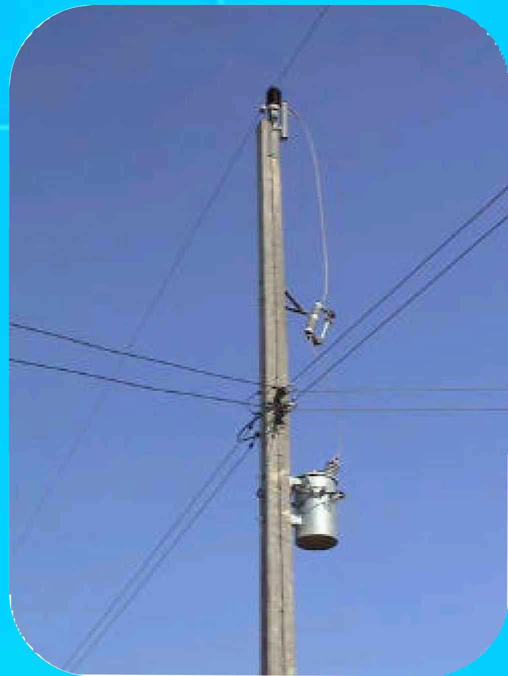
Isolating Transformer Impedances

- Rating = 200 kVA/phase
- RI = 0.016 pu
- XI = 0.038 pu
- RO = RO (+x) + R_E = 0.016 + 0.0012
  = 0.0172 pu
- XO = 0.038 pu
- Delta-Wye winding



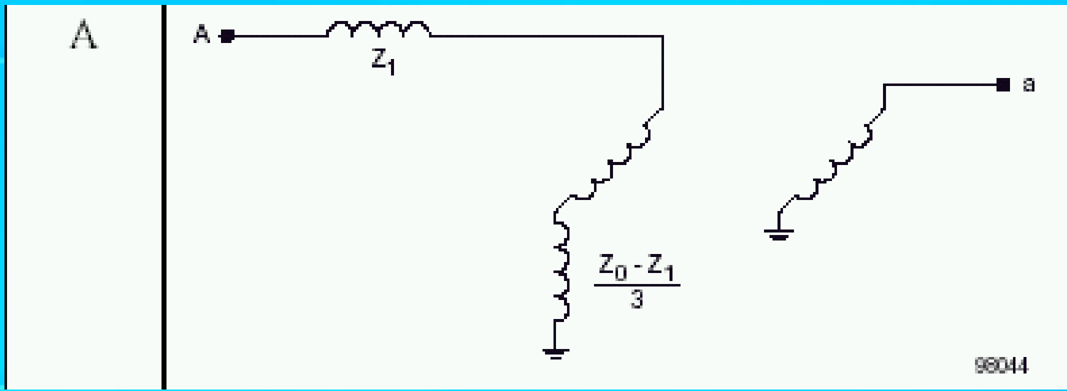
Modelling SWER Distribution Transformer

- HV Line Voltage = 12.7 kV
- LV Line Voltage = 230 V
- Rating = 25 kVA
- R = 2.6%
- X = 2.5%
- Earthing Resistance R_E = 10?
- Therefore $I_{base} = \dfrac{25kVA}{12.7kV} = 1.96A$
- $V\% = \dfrac{19.6V}{12.7kV} = 0.00154 = R_E$ (pu)



SWER Transformer Impedances

- Rating = 25 kVA/phase
- RI = 0.026 pu
- XI = 0.025 pu
- RO = RO (+x) + R_E = 0.026 + 0.00154
  = 0.02754 pu
- XO = 0.025 pu
- Wye-Wye winding



Modelling SWER Lines

- Resistance R1 = R (conductor) + R (earth return path) Allow 0.05 ohms/km at 50 Hz for earth return path. Note R1 = RO
- Reactance:
  - Earth return currents typically flow at average depth of 1500 metres
  - Increased separation causes approximately 0.46 ohms/higher reactance than metallic circuit at 50 Hz

Calculation of Geometric Mean Radius (GMR)

- GMR is a factor depending on physical and magnetic properties of the conductor

For Weasel ACSR: 6 strands Aluminium
1 strand Steel

For 6/1 stranded ACSR, GMR = 0.000358 d

Where: GMR (metres)
d, overall diameter (mm)

Calculation of Geometric Mean Distance (GMD)

- GMD is a function of the distance between conductor and its return path
- In SWER systems GMD is the depth of the current return path in the earth

GMD = $93\sqrt{?}$ (m)

Typically Soil resistivity ? = 250 ohm.m

So GMD = 1470 m

Inductive Reactance of SWER Line

- X1 = A(Inductive Reactance to 1 metre due to GMR)
  +B(Inductive Reactance spacing factor due to GMD

where $A = 0.1446 \log_{10} \dfrac{1}{GMR}$ ohm/km at 50 Hz

$B = 0.1446 \log_{10} GMD$ ohm/km at 50 Hz

Note: X1 = X0

SWER Modelling Tips

- Charging Admittances for SWER lines can be calculated using Line Properties Calculator. Set soil resistivity in Options > Setup > Corridor tab
- Voltage range between full load and minimum load is often challenging, particularly with fixed distribution transformer tap selection

SWER References

- *High Voltage Earth Return Distribution for Rural Areas*
  The Electricity Authority of New South Wales
  Fourth Edition, June 1978
- *When One Wire is Enough* Neil Chapman, Advance Energy
  Transmission & Distribution World, April 2001
- www.ruralpower.org
  A useful website setting out aspects of SWER systems for application in developing countries, containing other links and reference material, collated by Conrad Holland, Meritec

These sources are acknowledged as references for this presentaiton

Questions?

Contact Peter Armstrong:

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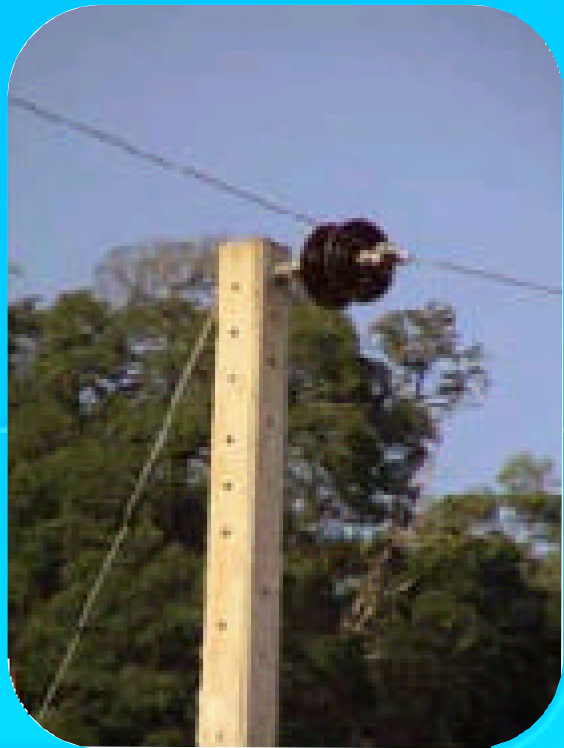

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