HB 219 Worked Example 3.6.3 Extensive Urban MEN System Supplied by a HV Overhead Line

2 km aerial HV feed to a pole-mounted distribution transformer, no OHEW, common HV/LV earth, extensive MEN (Australian type), LV neutral not bonded to HV source substation.

22 kV source, no NER.

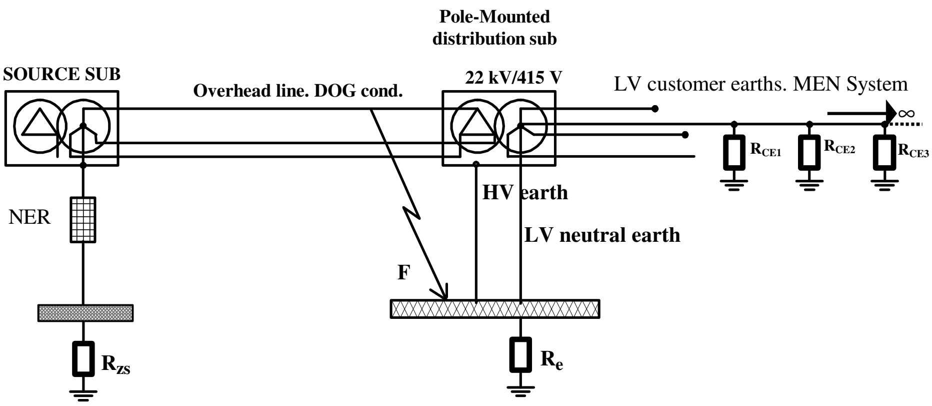


Fig. 3.6.3.1 Extensive urban MEN network supplied by a HV overhead line

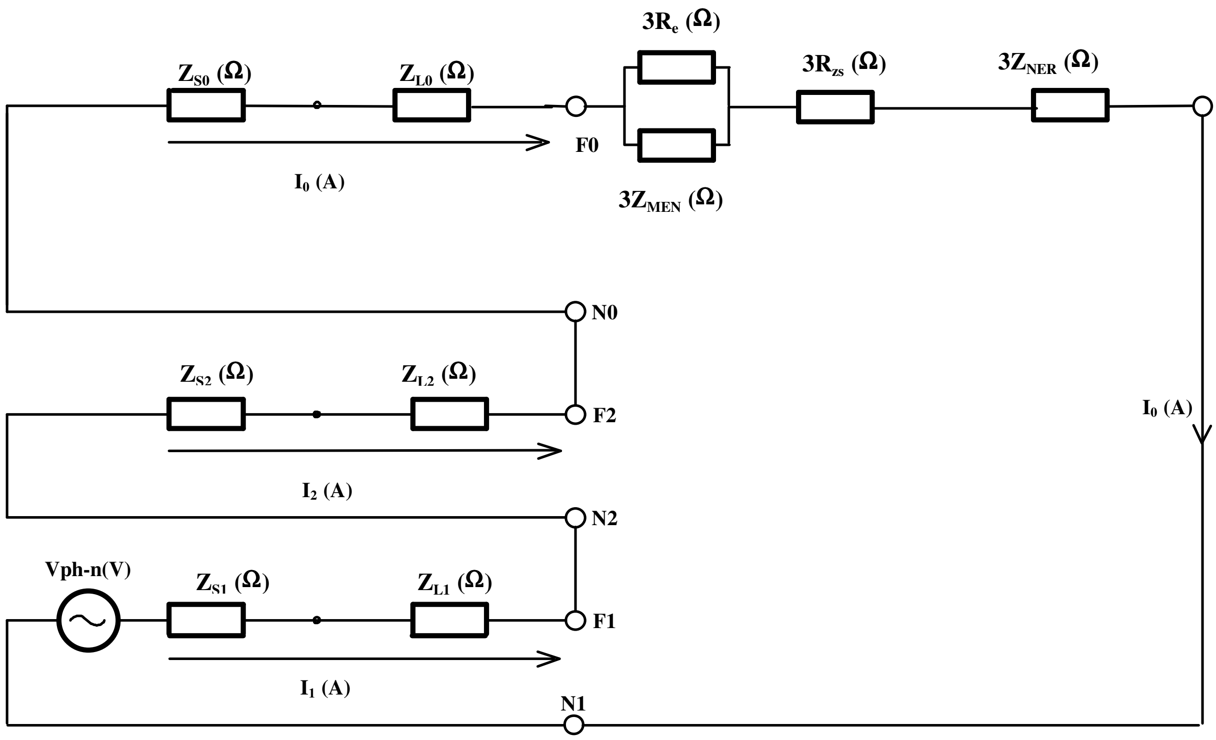


Fig. 3.6.3.2 Symmetrical components network for a HV single phase to earth fault at the distributio transformer.

22kV SYSTEM DATA

SOURCE VOLTAGE (Volts) & IMPEDANCE (Ohms)

Single phase source voltage V_{ph-n} (Volts) $Vs_1 := 12702$

Single Phase Fault Level S (MVA) $S := 400$

Source impedance calculated from the fault level. Assume source impedance is purely reactive and positive sequence = negative sequence = zero sequence.

Positive sequence source impedance (Ohms) $Z_{S1} := \frac{22^2}{S} \cdot j \qquad Z_{S1} = 1.210j$

Negative sequence source impedance (Ohms) $Z_{S2} := Z_{S1}$

Zero sequence source impedance (Ohms) $Z_{S0} := Z_{S1}$

22kV Overhead line impedance

Conductor size: DOG (6/4.72mm aluminium with 7/1.57mm steel)

Length (km) $L := 2.0$

Line sequence impedances (Ohms/km)

Positive sequence line impedance (Ohms/km) $Z_{L1} := 0.2722 + 0.3407j$

Negative sequence line impedance (Ohms/km) $Z_{L2} := Z_{L1}$

Zero sequence line impedance (Ohms/km) $Z_{L0} := 0.4204 + 1.6545j$

22kV NER AND EARTHING IMPEDANCE (Ohms)

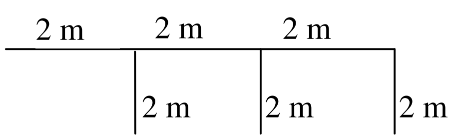
Neutral Earthing Resistor (Ohms) $Z_{NER} := 0$

Zone substation earthing system resistance (Ohms) $R_{zs} := 0.01$

Surface soil resistivity (Ohm-m) $\rho := 10$ Ohm-m

MEN impedance of typical urban extensive MEN system (see HB 219 Worked Example 4.1.2 for the derivation of this value) (Ohms) $Z_{MEN} := 0.084 + 0.063j$

Distribution transformer earthing system



All rods 2 m long and 14 mm dia.

Transformer earthing system resistance (Ohms) $R_e := 0.14 \cdot \rho \qquad R_e = 1.400$

The equivalent hemispherical radius (m) $r_E := \frac{\rho}{2 \cdot \pi \cdot R_e} \qquad r_E = 1.137$

Equivalent MEN plus Re impedance (Ohm) $Z_{eq} := \left(\frac{1}{Z_{MEN}} + \frac{1}{R_e} \right)^{-1}$

$Z_{eq} = 0.082 + 0.056j$

CALCULATIONS

One Phase to Earth fault on the 22kV feeder at the distribution transformer

Sequence network impedance (Ohms)

$Z_{pos} := Z_{S1} + Z_{L1} \cdot L$ $\quad Z_{neg} := Z_{S2} + Z_{L2} \cdot L$ $\quad Z_{zero} := Z_{S0} + Z_{L0} \cdot L + 3 \cdot Z_{eq} + 3 \cdot R_{zs}$

$Z_{pos} = 0.544 + 1.891j$ $\quad Z_{neg} = 0.544 + 1.891j$ $\quad Z_{zero} = 1.116 + 4.687j$

Zero sequence fault current (Amps)

$$I_0 := \frac{Vs_1}{Z_{pos} + Z_{neg} + Z_{zero} + 3 \cdot Z_{NER}}$$

Fault current (Amps) $\quad I_f := 3 \cdot I_0 \quad I_f = 1096.7 - 4213.6j \quad |I_f| = 4354.0$

EPR at the distribution transformer (Volts)

$EPR_{dt} := I_f \cdot Z_{eq} \quad |EPR_{dt}| = 431$