<u>HB 219 Worked Example 3.6.1</u> 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 eartl extensive MEN, LV neutral not bonded to HV source substation.

11 kV source, no NER.

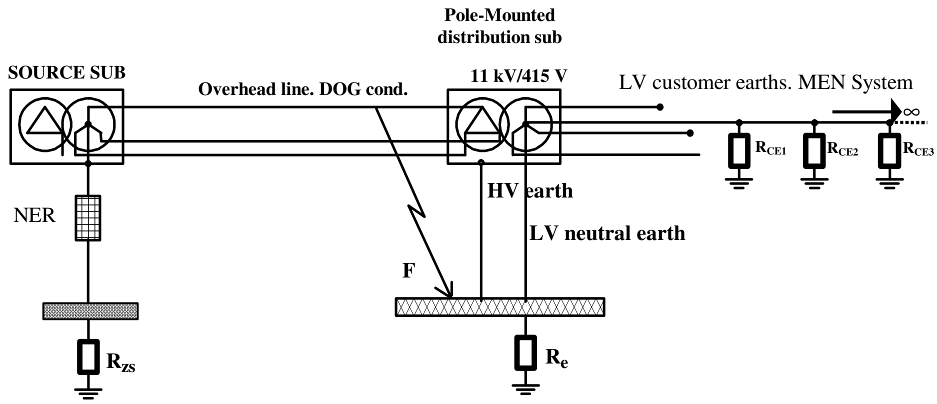


Fig. 3.6.1.1 Extensive urban MEN network supplied by a HV overhead line

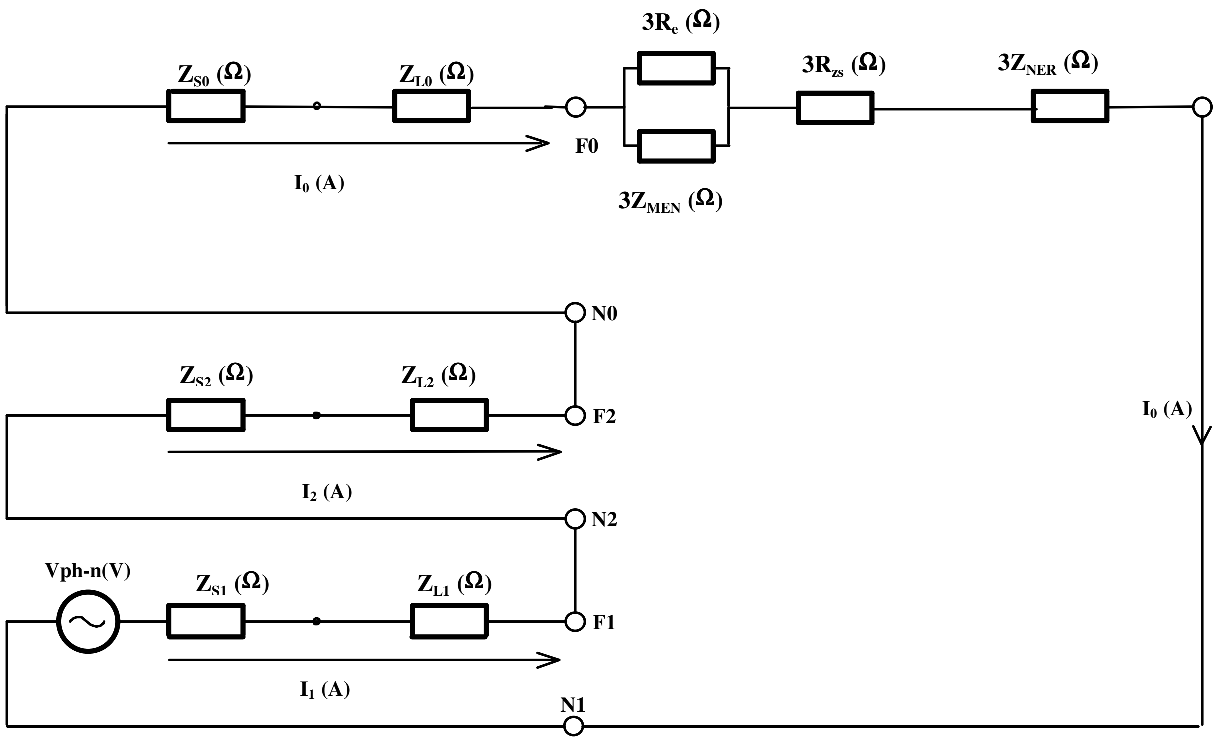


Fig 3.6.1.2 Symmetrical components network for a HV single phase to earth fault at the distribution transformer.

11kV SYSTEM DATA

SOURCE VOLTAGE (volts) & IMPEDANCE (Ohms)

Single phase source voltage V_{ph-n} (Volts) $Vs_1 := 6350$

Single Phase Fault Level S (MVA) $S := 200$

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) $Z_{S1} := \frac{11^2}{S} \cdot j$ $Z_{S1} = 0.6j$

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

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

11kV Overhead line impedance

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

Length (km) $L := 1.0$

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) $Z_{L0} := 0.4204 + 1.6545j$

11kV NER AND EARTHING IMPEDANCE (Ohms)

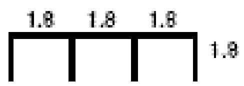
Neutral Earthing Resistor (Ohms) $Z_{NER} := 0$

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 4.1.1 for the derivation of this value) (Ohms) $Z_{MEN} := 0.103 + 0.076j$

Distribution transformer earthing system



Transformer earthing system resistance (Ohms) $R_e := 0.1346 \cdot \rho$ $R_e = 1.3$

The equivalent hemispherical radius (m) $r_E := \frac{\rho}{2 \cdot \pi \cdot R_e}$ $r_E = 1.18$

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

$Z_{eq} = 0.10 + 0.07j$

CALCULATIONS

One Phase to Earth fault on the 11kV feeder at the distribution transformer

Sequence network impedances (Ohms)

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

$Z_{pos} = 0.3 + 0.9j$ $Z_{neg} = 0.3 + 0.9j$ $Z_{zero} = 0.7 + 2.5j$

Zero sequence fault current (Amps) $I_0 := \frac{Vs_1}{Z_{pos} + Z_{neg} + Z_{zero} + 3 \cdot Z_{NER}}$

Fault current (Amps). $I_f := 3 \cdot I_0$ $I_f = 1196.8 - 4026.5j$ $|I_f| = 4200.6$

EPR at the distribution transformer (Volts)

$EPR_{dt} := I_f \cdot Z_{eq}$ $|EPR_{dt}| = 499$