HB 219 Worked Example 3.7.1 Extensive Urban MEN System Supplied by a HV Buried Cable

1 km underground HV feed to a pad-mounted distribution transformer, common HV/LV earth, extensive MEN, LV neutral bonded to HV source substation via HV cable sheath.

11 kV source, no NER.

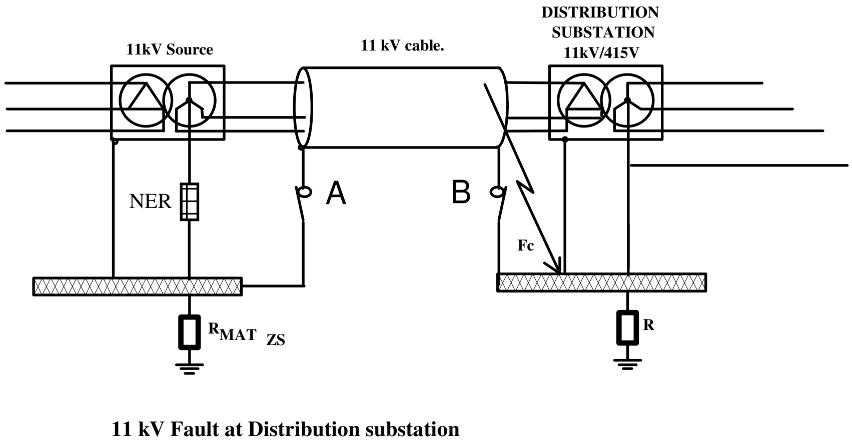


Fig. 3.7.1.1 Extensive urban MEN system supplied by a 11kV buried cable

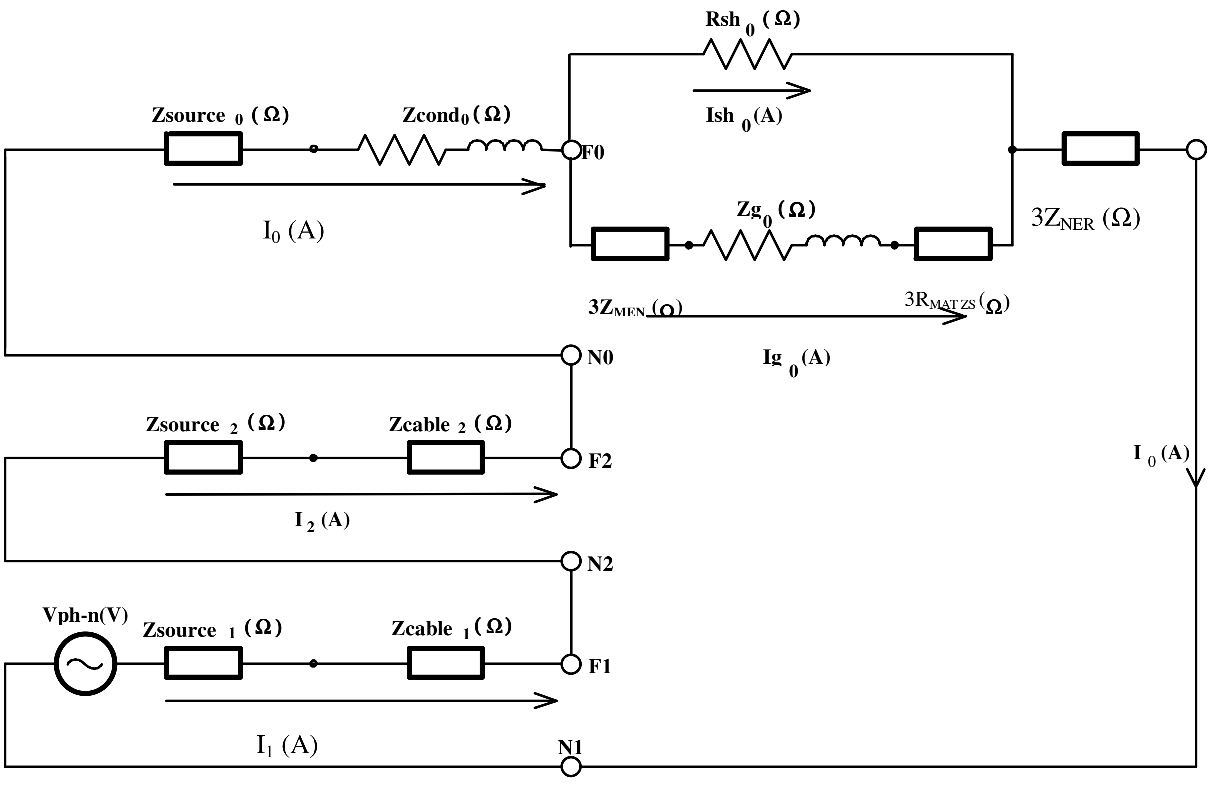


Fig 3.7.1.2 Symmetrical components network for a HV single phase to earth fault at the distribution transformer

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) $Z_{S1} := \frac{11^2}{S} \cdot j$ $Z_{S1} = 0.605j$

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

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

11kV distribution cable impedance

Cable size and Type: **150 sqmm Al Belted PILCPS** Length (km) $C := 1.0$

Cable sequence impedances (Ohms/km)

Positive sequence cable impedance (Ohms/km) $Z_{C1} := 0.2078 + 0.0773j$

Negative sequence cable impedance (Ohms/km) $Z_{C2} := Z_{C1}$

Zero sequence cable impedance (Ohms/km) $Z_{cond0} := 0.2062 + 0.1142j$

$R_{sh0} := 2.6612$

$Z_{g0} := 0.1480 + 2.0779j$

11kV NER AND EARTHING IMPEDANCE (Ohms)

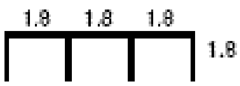
Neutral Earthing Resistor (Ohms) $Z_{NER} := 0$

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

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) $R_e := 0.1346 \cdot \rho$ $R_e = 1.346$

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)

$Z_{pos} := Z_{S1} + Z_{C1} \cdot C$

$Z_{neg} := Z_{S2} + Z_{C2} \cdot C$

$Z_{pos} = 0.2078 + 0.6823j$

$Z_{neg} = 0.2078 + 0.6823j$

$$Z_{zero} := Z_{S0} + Z_{cond0} \cdot C + \left(\frac{1}{R_{sh0} \cdot C} + \frac{1}{3 \cdot Z_{eq} + Z_{g0} \cdot C + 3 \cdot R_{MATZS}} \right)^{-1}$$

$Z_{zero} = 1.3875 + 1.7922j$

Zero sequence fault current (Amps)

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

Zero sequence fault current returning via earth (Amps)

$$I_{g0} := I_0 \cdot \frac{R_{sh0} \cdot C}{R_{sh0} \cdot C + 3 \cdot Z_{eq} + Z_{g0} \cdot C + 3 \cdot R_{MATZS}}$$

$I_{g0} = -129.786 - 1192.771j$

$\left| I_{g0} \right| = 1199.811$

Fault current returning via earth (Amps)

$I_g := 3 \cdot I_{g0}$

$\left| I_g \right| = 3599.433$

EPR at the distribution transformer (Volts)

$EPR_{dt} := I_g \cdot Z_{eq}$

$\left| EPR_{dt} \right| = 427$