

## HB 219 Worked Example 3.3.2 Fault at 11 kV Concrete or Steel Pole

10km aerial HV feed, no OHEW.

11 kV source, 4 ohm NER.

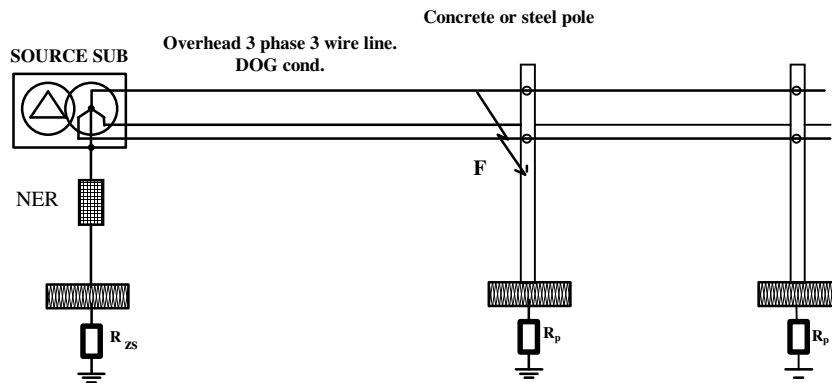


Fig 3.3.2.1 Fault at 11kV concrete or steel pole

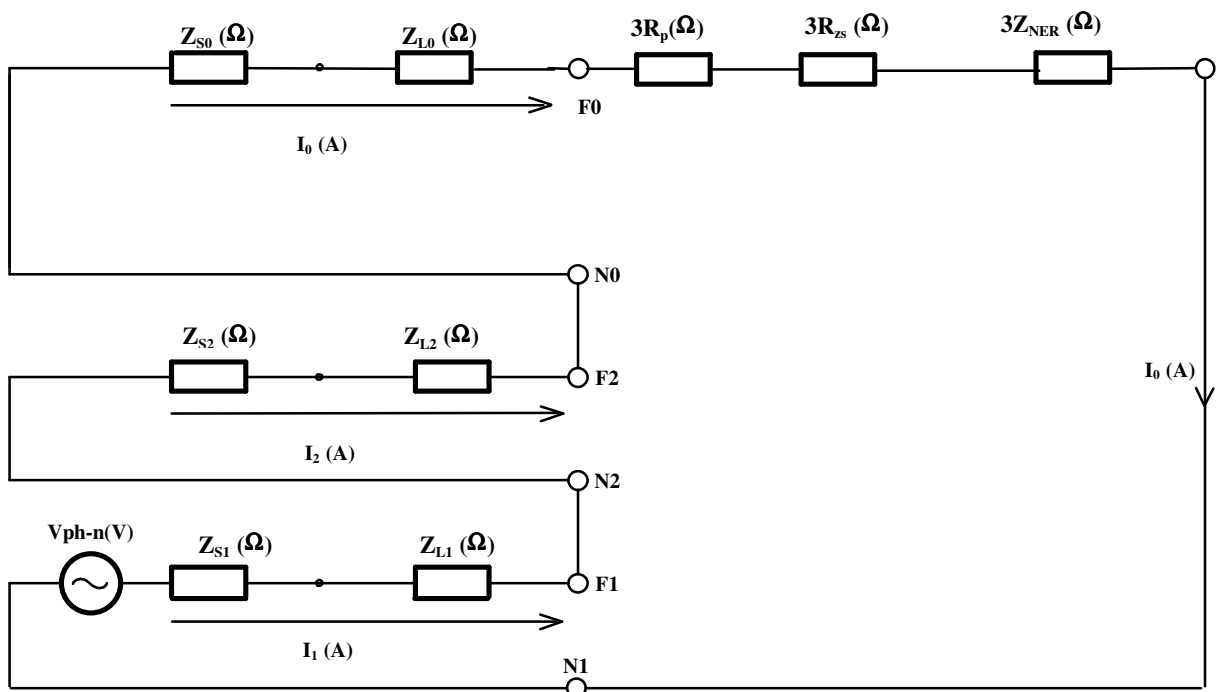


Fig 3.3.2.2 Symmetrical components network for a HV single phase to earth fault at the pole

## 11kV SYSTEM DATA

### SOURCE VOLTAGE (volts) & IMPEDANCE (Ohms)

Single phase source voltage  $V_{ph-n}$  (Volts)

$$V_{s1} := 6350$$

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 impedance.

Positive sequence source impedance (Ohms)

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

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)

$$L := 10.0$$

### 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)

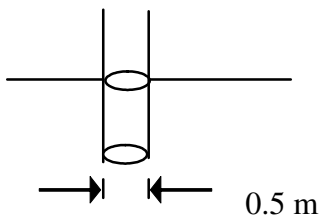
$$Z_{NER} := 4$$

Zone substation earthing system resistance (Ohms)

$$R_{zs} := 0.01$$

Surface soil resistivity (Ohm-m)

$$\rho := 10 \quad \text{Ohm-m}$$



Each pole 2 m deep in soil and 0.5 m dia.

Pole earth resistance (Ohms)

$$R_p := 0.17 \cdot \rho$$

$$R_p = 1.700$$

The equivalent hemispherical radius (m)

$$r_E := \frac{\rho}{2 \cdot \pi \cdot R_p}$$

$$r_E = 0.936$$

## CALCULATIONS

One Phase to Earth fault on the 11kV feeder at a conductive pole

Sequence network impedance (Ohms)

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

$$Z_{\text{pos}} = 2.722 + 4.012j \quad Z_{\text{neg}} = 2.722 + 4.012j \quad Z_{\text{zero}} = 9.334 + 17.150j$$

Zero sequence fault current (Amps)

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

Fault current (Amps)

$$I_f := 3 \cdot I_0 \quad I_f = 377.6 - 355.0j \quad |I_f| = 518.3$$

EPR at the conductive pole (Volts)

$$\text{EPR}_{\text{pole}} := I_f \cdot R_p \quad |\text{EPR}_{\text{pole}}| = 881$$

