HB 219 Worked Example 3.3.1 Fault at 11 kV Concrete or Steel Pole

5 km aerial HV feed, no OHEW.

11 kV source, no NER.

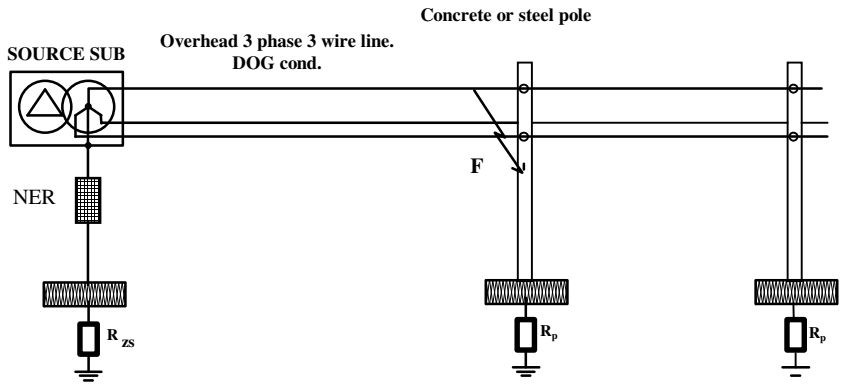


Fig. 3.3.1.1 Fault at 11kV concrete or steel pole

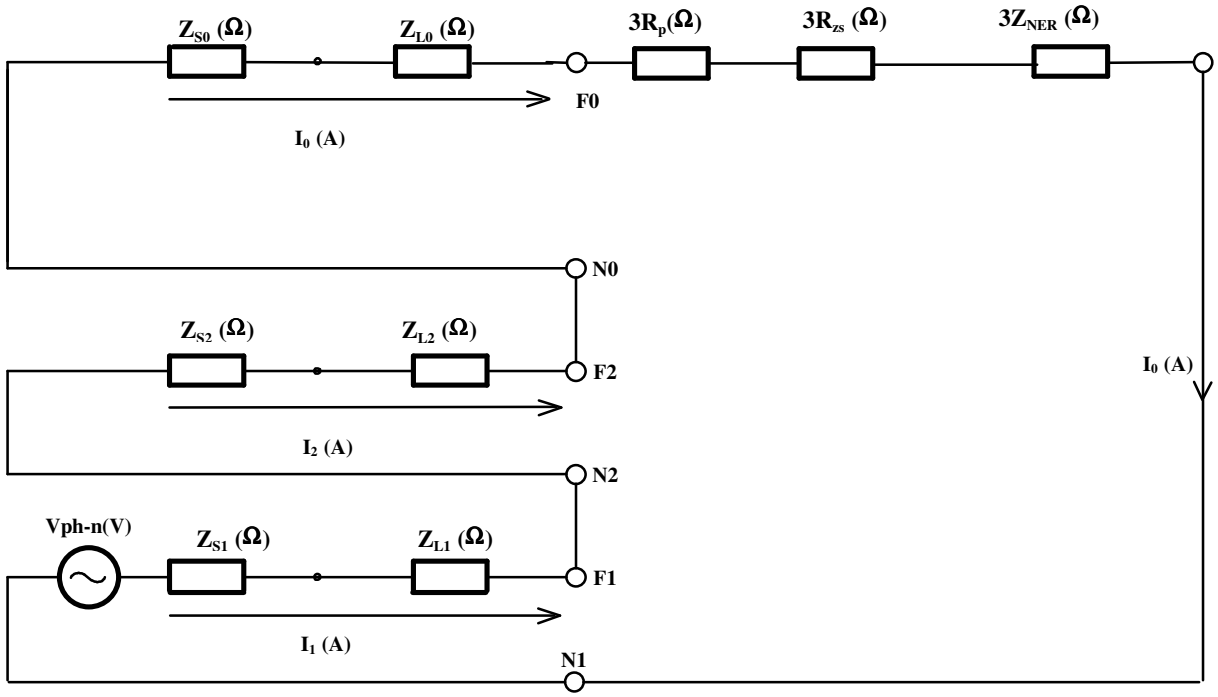


Fig. 3.3.1.2 Symmetrical components network for a HV single phase to earth fault at the pole.

11kV SYSTEM DATA

SOURCE VOLTAGE (volts) & IMPEDANCE (Ohms)

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

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 impedance.

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 Overhead line impedance

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

Length (km) $L := 5.0$

Line sequence impedances (Ohms/km)

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

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

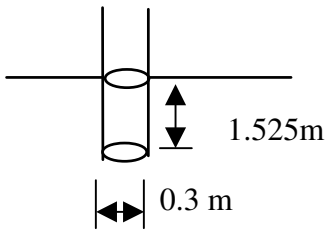
Zero sequence line impedance (Ohms/km) $Z_{L0} := 0.4204 + 1.6545j$

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



Each pole 1.525 m deep in soil and 0.3 m dia.

Pole earth resistance (Ohms) $R_p := 0.309 \cdot \rho$ $R_p = 3.090$

The equivalent hemispherical radius (m) $r_E := \frac{\rho}{2 \cdot \pi \cdot R_p}$ $r_E = 0.515$

CALCULATIONS

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

Sequence network impedance (Ohms)

$Z_{pos} := Z_{S1} + Z_{L1} \cdot L$ $\quad Z_{pos} = 1.361 + 2.309j$

$Z_{neg} := Z_{S2} + Z_{L2} \cdot L$ $\quad Z_{neg} = 1.361 + 2.309j$

$Z_{zero} := Z_{S0} + Z_{L0} \cdot L + 3 \cdot R_p + 3 \cdot R_{zs}$ $\quad Z_{zero} = 11.402 + 8.878j$

Zero sequence fault current (Amps)

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

Fault current (Amps)

$I_f := 3 \cdot I_0$ $\quad I_f = 705.1 - 673.7j$ $\quad |I_f| = 975.2$

EPR at the conductive pole (Volts)

$EPR_{pole} := I_f \cdot R_p$ $\quad |EPR_{pole}| = 3013$