Question 1 (Relay Protection) 60% of the relay protection part:

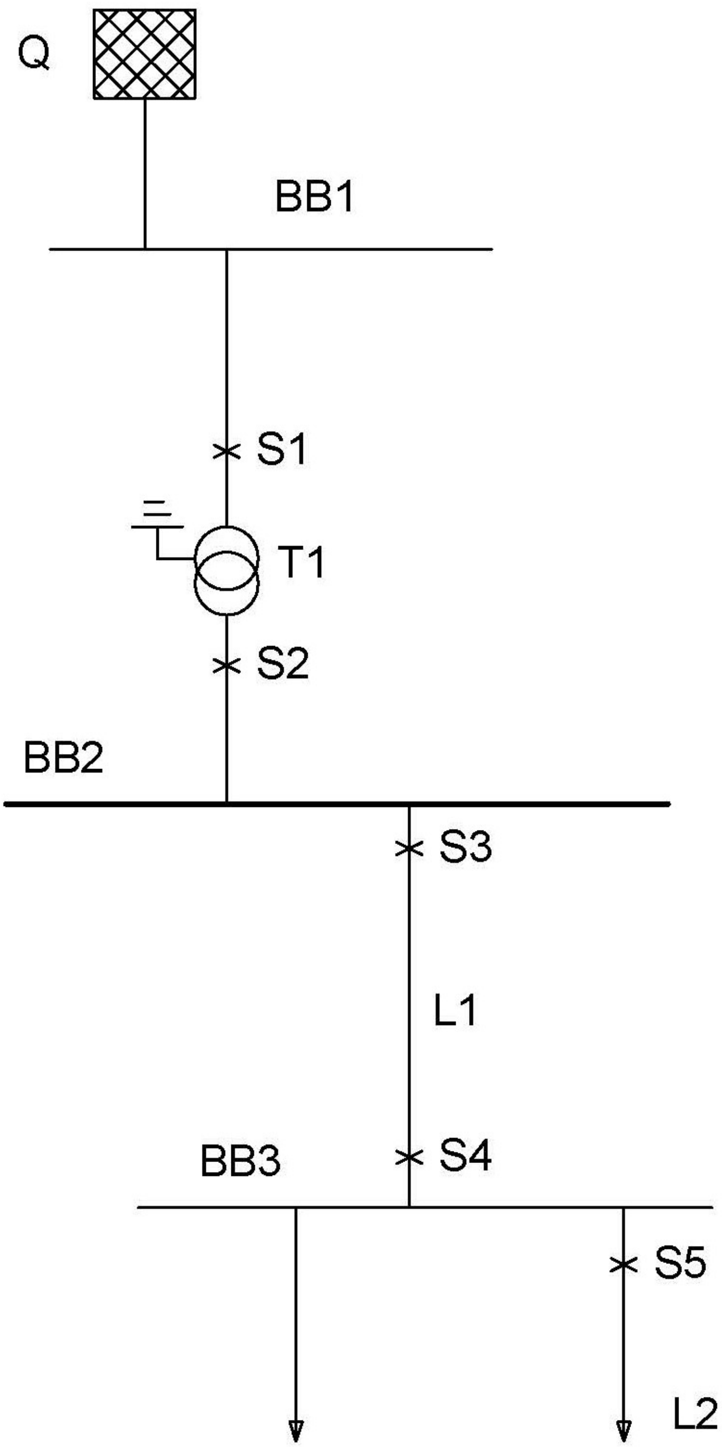


Fig.1

Data for the network in Fig.1:

Component	Nominal values
Q1	S"k = 650 MVA R= 0.1X Un = 72 kV, ref. BB1
T1	Sn = 20 MVA ez= 9 % ez0 (seen from 70 kV side) = 12 % er = 0,7 % Un1/Un2 = 70 /22 kV YNy0
L1	$Z_{1,2}$ = 0,05 + j0,037 ohm/ km Z_0 = 0,08 + j0,14 ohm/km l = 30 km
L2	$Z_{1,2}$ = 0,05 + j0,037 ohm/ km Z_0 = 0,08 + j0,14 ohm/km l = 30 km
Overcurrent relays	Pick-up/drop-off ratio=0.95; Time delay=0.25 sec

We have a distribution network with nominal voltages 72 / 24 kV (note that the transformer has different nominal voltages). The infeed is at the 72 kV side. The 20 kV side of the transformer is insulated neutral point with possibility to install an inductive compensation coil (Petersen coil).

a. Calculate the three phase symmetrical short circuit current at BB3.
b. Calculate I_S at BB3.
c. Calculate the two pole short circuit current without earth fault at BB3.
d. How would you choose c and line resistance for the minimum fault current? No calculation is necessary, just explanation in your own words.
e. Max. power transmission at L1 is 4MW with cosΦ=0.8. S3 is connected to an overcurrent relay with time delay 0.5 sec. S4 does not have a relay on its own but receives signal from the relay at S3 so that they both break simultaneously. Find a reasonable set-up for the overcurrent relay at S3.

f. We want to protect T1 such that the breakers trip instantaneously for any failure at T1, even for small currents. What kind of protection should we use?
g. We want to install a Petersen coil at the secondary of T1. The capacitance per phase of the feeder from T1 can vary between 1.5 and 3µF. What are the maximum and minimum inductance values for the coil?
h. In order to detect earth fault, U_0 is measured at the 24 kV side. Explain how this can be done with the help of three single-phase voltage transformers with open delta on the secondary.

Question 2 (Relay Protection) 40% of the relay protection part:

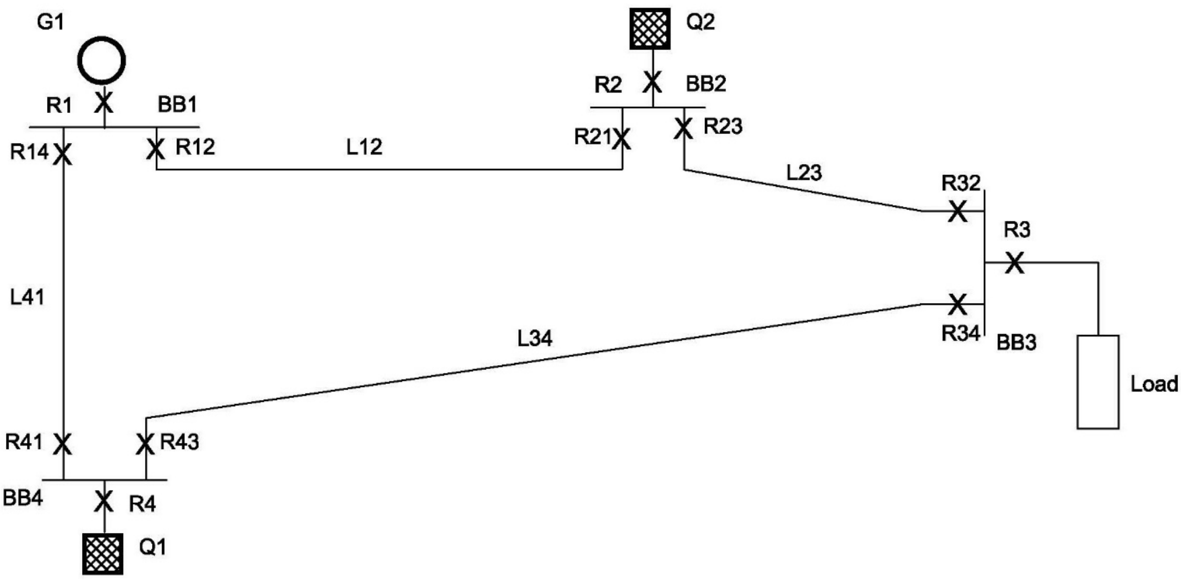


Fig. 2

On Fig.2, you see a high voltage system. We have four busbars BB1 - BB4, two infeed Q1 - Q2, one generator G1 and a load connected to BB3.

R1, R2, R3, R4 are overcurrent relays. All other relays are distance relays. For the distance relays we have following parameters:

Δt1 (for Zone 1) = 0;

Δt2 (for Zone 2) = 0.5s;

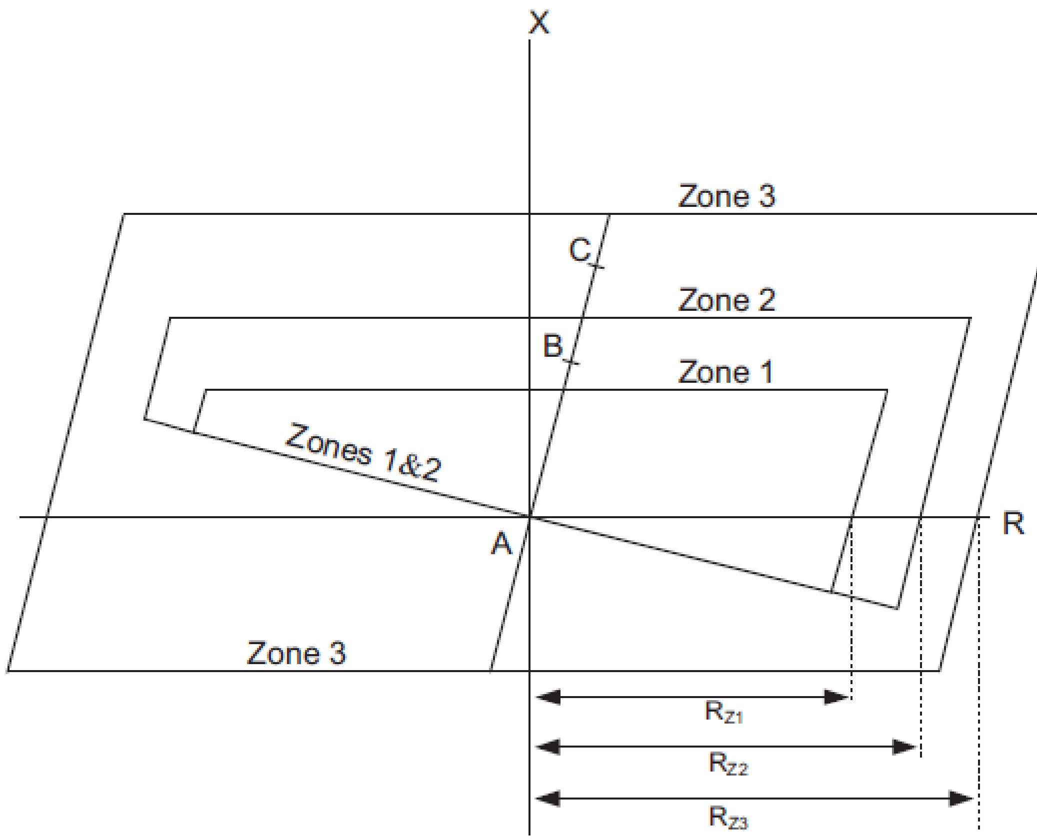
Δt3 (for Zone 3) = 1.1s.

The values for the lines are:

Line	Length, impedance (all lines have same impedance per km)
L12	300 km, Z=0.03+j0.42 Ω/km
L23	200 km, Z=0.03+j0.42 Ω/km
L34	350 km, Z=0.03+j0.42 Ω/km
L41	250 km, Z=0.03+j0.42 Ω/km

At first, you can only work with lengths since line parameters are the same.

a) Draw a figure that explains the settings for Z1, Z2 and Z3 for relays R23 and R32.
b) We have a fault on L23, 30 km. from BB3. Make a table of how each distance relay will pick up the fault (Z1, Z2 or Z3) and how they will react. Which relays will trip, when and which relays will reset, when.
c) How would the relays react if R32is out of order? Take also into consideration the overcurrent relays.
d) Now you must consider line impedances. How would you set up the impedance values for Zone1, Zone 2 and Zone 3 at relay R32? Use this figure to set values.



e) It is required that all the relays must react as quickly as possible (assume all are working properly). You will set up a PUTT scheme for all the pairs. Draw a sketch to explain how this scheme will work for R23 and R32.