**Homework isolated and resonance grounded neutrals**

Given a 22 kV distribution system as shown in Fig. 1. The system is supplied from 132 kV and has an insulated neutral. From the transformer station (bus SSK1) there are two cable feeders to bus 3 and 2 and further overhead line distribution on bus 2. Cable 1, CBL1 has capacitance $C_1$=100 nF per phase and cable 2, CBL2 has capacitance $C_2$=150 nF per phase. The overhead lines (out from bus SSK 2) have capacitance to ground of 5.0 nF/km per phase and lengths as given in Fig.1.

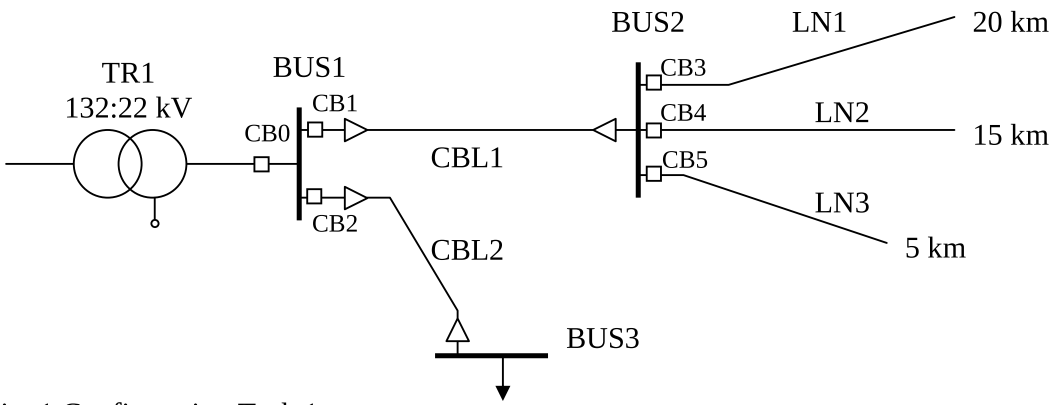


Fig. 1 Configuration Task 1

A) Define the concept *Selectivity*. How can we coordinate over-current relays for the circuit breakers CB0-CB5 to achieve selectivity? Indicate time delays for each relay.

B) Assume now that a distributed generator is installed at bus 3. How can selectivity now be obtained? Indicate time delays for the involved breakers CB0-CB5 for non-directional over-current relays.

C) A ground fault occurs on line LN1. Determine the ground fault current, $I_f$, for a fault resistance of $R_f$=3 kΩ. What is the zero sequence current out on the two cable feeders from the bus 1? How can we obtain selectivity in this case?

$$I_f = \frac{U_p}{R_f + \frac{1}{j\omega \cdot 3 \cdot \sum C}}, \quad 3I_{0,k} = \begin{cases} -I_f \cdot \frac{C_k}{\sum_n C_n}, & \text{healthy feeder} \\ \sum_{n \neq k} I_{0,n}, & \text{faulty feeder} \end{cases}$$

D) The neutral grounding of transformer TR1 is now changed to resonance grounding. What are the pros and cons of this grounding principle? Determine the size of the inductor at resonance and at 110% over-compensation. What determines the maximum neutral pre-fault voltage and the fault current? A parallel resistance to the neutral inductor will improve the sensitivity of the protection, how?