

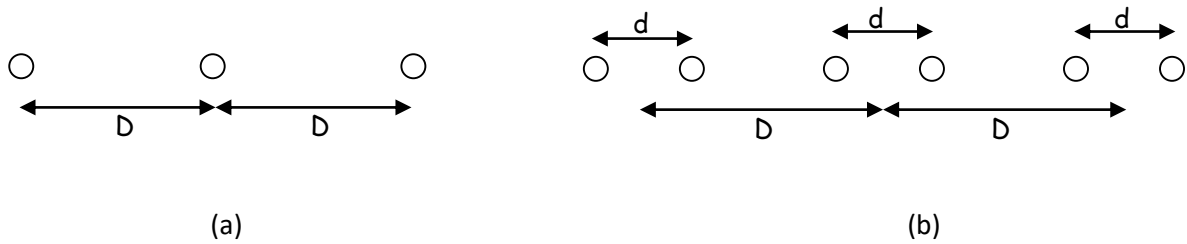
TD2: Electrical Transmission Lines

Exercise 1

A 230kV three-phase power line is 100km long. Each conductor has a radius of 1.5189cm and a GMR equal to 1.2283cm. Calculate in both cases (figure below):

- 1) the inductance and then the reactance per phase of the line;
- 2) the line-to-neutral capacitance, the shunt admittance, the charging current per phase, and the total reactive power supplied by the line capacitance.

We are given $D = 6m$ and $d = 0.3m$.



Exercise 2

A three phase, 50Hz transposed transmission line has a flat horizontal configuration. The line reactance is 0.405Ω per kilometer. The conductor radius is 2.568cm. Determine the phase spacing D .

Exercise 3

A 33kV, three phase transmission line supplies a load of 1000kW at a lagging power factor of 0.8. If the per-phase resistance and reactance of the line is 20Ω and 50Ω, respectively, what will be the required sending end voltage if 33kV is to be maintained at the receiving end? Also compute a) sending end real power, b) line loss, c) efficiency; and d) per cent regulation.

Exercise 4

The electrical parameters per phase and per kilometer of a 220kV three-phase line, 150km long, are 0.08Ω, 1.6mH, and 0.01μF. The voltage at the receiving end is 220kV for a load of 250MW with a power factor of 0.9 lagging. Calculate the voltage and current at the sending end, and then the efficiency of the line using the medium-line model. Calculate the voltage regulation.

Exercise 5

A 360kV three-phase line of length 80km has an impedance $Z = (5 + j40) \Omega$. The angle δ is the phase shift between the voltage at the sending end and the voltage at the receiving end. Calculate the active and reactive powers at the ends of the line and the losses in the line in the following cases:

- a) $U_S = U_R = 360kV$ and $\delta = 10^\circ$
- b) $U_S = 360kV, U_R = 375kV$ and $\delta = 10^\circ$
- c) $U_S = 360kV, U_R = 375kV$ and $\delta = 15^\circ$

Compare the results obtained from the point of view of the direction of power flow.

Exercise 6

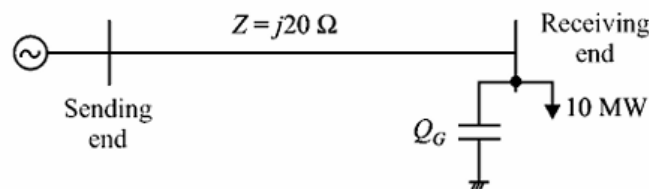
A transmission line with an impedance of $(0 + 50j) \Omega$ connects two networks A and B operating at a voltage of $120kV$. The maximum power that the line can transfer is $P_{max} = 288 MW$.

- 1) Series compensation is introduced into the line to increase P_{max} to $480 MW$. What is the value of the capacitor that needs to be inserted per phase?
- 2) If we want to transfer $300 MVA$, what would be the voltage across this capacitor?

Exercise 7

Figure below shows a three-phase, $33kV$ line feeding a per-phase load of $10 MW$.

- 1) If the impedance of the line is $Z = j20 \Omega$, determine the load angle and the reactive power to be supplied by the capacitive source connected at the load end to maintain a line voltage of $33kV$ at the load.
- 2) If the capacitive source is removed, what is the maximum real power load which can be supplied? What will be the power angle and the voltage to supply the load?



Exercise 8

A $300km$ long transmission line supplies a $400MVA$, 0.8 lagging power factor load at $345kV$. The ABCD parameters of this line are: $A = D = 0.8180 \angle 1.3^\circ$; $B = 172.2 \angle 84.2^\circ \Omega$; $C = 0.001933 \angle 90.4^\circ S$.

- 1) Calculate V_S , I_S and $\Delta V(\%)$;
- 2) Determine V_{R0} , I_{S0} and V_R .

A capacitor bank is installed in series in the middle of the above line. The ABCD parameters of the capacitor bank are: $A = D = 1 \angle 0^\circ$; $B = 146.6 \angle -90^\circ \Omega$; $C = 0$.

The ABCD parameters for $150km$ of the line are:

$$A = D = 0.9534 \angle 0.3^\circ ; B = 90.33 \angle 84.1^\circ \Omega ; C = 0.001014 \angle 90.1^\circ S.$$

Determine the equivalent ABCD parameters of the series combination of line-capacitor-line.

Repeat questions 1) and 2).

Exercise 9

A $66kV$, $60km$ long line delivers a load of $25MW$ at 0.8 lagging power factor. If the line has a series resistance and inductance of $0.08 \Omega/km$ and $1.25mH/km$, respectively, compute a) sending end voltage and current, b) voltage regulation, and c) transmission efficiency. Assume a power frequency of $50 Hz$.

Exercise 10

A $132kV$ three-phase transmission line has the following parameters:

$$A = 0.9696 \angle 0.49^\circ ; B = 52.88 \angle 74.79^\circ \Omega ; C = 0.001177 \angle 90.15^\circ S$$

If the voltage at the receiving end is $132kV$ for a load of $125MVA$ and 0.9 lagging power factor, calculate the voltage and current at the sending end.