1)

a) What is the approximate formula for calculating the voltage drop in the line voltage of a feeder in terms of *I*, *R*, *X* and φ?

b) Derive the previous formula in task 1a) using active power *P* instead of current *I*.

c) Derive the formula in terms of active power *P* and reactive power *Q*

d) A medium voltage feeder supplies a single load where P = 2.6 MW, Q_{ind} = 1.1 Mvar. The load is situated 10 km from the substation. The voltage at the load is 20.5 kV and the feeder impedance is $\underline{z}$ = (0.5+j0.38) Ω/km.

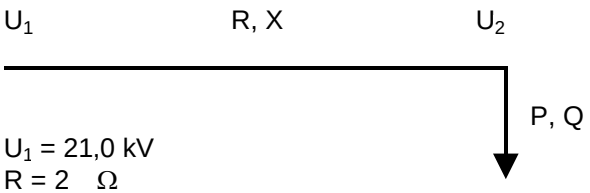
What is the approximate voltage drop in the feeder?

e) What is the approximate voltage drop using the more accurate formula?

f) What is the approximate voltage drop if the power factor is leading?

g) What is the voltage drop if the power factor is leading using the more accurate formula?

2)



U_1 = 21,0 kV
R = 2 Ω
X = 4 Ω
P = -700,0 kW
Q = 0

In the Figure above, all the other values are known, except the voltage at the far end U_2. Calculate the voltage rise using the various methods.

3)

A new MV (20 kV) feeder is planned, to feed a demand dominated substation 5km away, and two distributed generation-dominated substations, a further 10 and 5 km from the primary substation. The accountant wants to use the smallest (and cheapest) cable, and says that an engineer thinks the smallest cable (50 mm2 Al conductor) in the table in ED&M03 slide 10 will be OK, as it can handle the maximum demand-dominated loading at the end of a 20 year period of 3 %/annum load growth. You agree, but remembering the course Electricity Distribution and Markets you took at Aalto, you mention that thermal loading is only one parameter, the situation with the sun shining and the wind blowing needs to be checked, and that (at least) voltage should also be checked…

Table 1 Maximum and minimum demands at each substation, before and after the 20 year projected load growth of 3 %/annum covering both demand and distributed generation.

Node	$P_{max,0}$		$P_{max,}$		$Q_{max,0}$	$Q_{max,20}$	$Q_{comp,20}$	$P_{min,0}$	$P_{min,20}$	$Q_{min,0}$	$Q_{min,20}$	$Q_{comp,20}$
	(kW)				(kvar)			(kW)		(kvar)		
0	0		0		0	0	0	0	0	0	0	0
1	650		1174		214	387	0	217	391	71	129	0
2	700		1264		230	425	0	-2000	-3612	0	0	0
3	700		1264		230	425	0	-2000	-3612	0	0	0

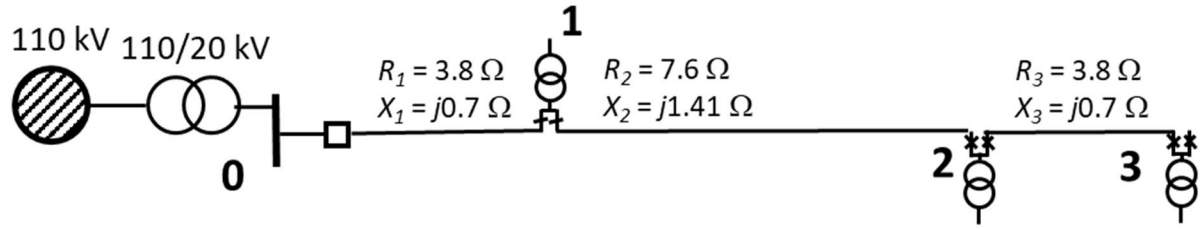


Figure 1 Resistances and reactances of the AHXAMK-W 3x50Al+35Cu 20 kV Wiski cable, which has lengths of 5 km, 10 km and 5 km for line sections 1, 2 and 3, respectively.

Check the cable system for ampacity, i.e. make sure the maximum loading doesn't cause currents greater than 155 A.

Check the cable system for voltage, setting a limit of 10% for voltage drop and 5% for voltage rise. If these limits are exceeded, what can you do about it?