Examination in Electrical Power Engineering and System Integration (5EE40)

Monday, 17th of November 2003 9.00h – 12.00h

First read all problems and start with the simplest one

Problem 1: (2 points)
The following loads are measured at a 10kV (line voltage) substation:
Load 1: 120kW, cosφ = 0.9 (inductive)
Load 2: 60 kVA, 30 kVAr
Load 3: 85 kW
Load 4: 55kVA, cosφ = 0.5 (inductive)

a) Calculate the active, reactive and apparent power of the station
b) The cosφ at the substation should be compensated to the value 0.96. Therefore, a capacitor bank in Δ-connection should be used. Calculate the total capacitance of the capacitors.

Problem 2: (1 point)
A synchronous generator (alternator) is connected to the electric utility grid where its terminal voltage may be considered constant. The field current is increased by 10 percent while the power supplied by the prime mover is not changed.
Neglect Rs and assume lagging power factor.

Describe qualitatively (build the phasor diagram with written comments) the changes in E_f, δ, I_a, θ, $Q_{3\phi}$ if for this small change in I_f, the X_s can be assumed constant.

Problem 3: (1 point)
In a single-phase full-bridge inverter, the input dc voltage amounts 300V. The modulation index m_a is set equal to 0.75, together with a modulation frequency f_o = 25Hz. The inverter is feeding a mixed load consisting of a resistor R= 500Ω and an inductor L= 1.0H.

Calculate the active power produced by the inverter.

Problem 4: (2 points)
A three-phase network with a line voltage 10 kV and a short-circuit power of 200 MVA supplies a high-voltage station. A short-circuit in one of the feeders causes a voltage drop in the station. The impedance of the short-circuited line is 0.117+j0.315 ohm /km.

a) Calculate the short-circuit impedance Z_k of the supplying network (the ohmic part can be neglected)
b) Calculate the relative voltage sag at the station if the sort-circuit happens in distance to the station of 1km and 10km, respectively.

Problem 5: (2 points)
A distribution network connected to the transmission grid is shown in figure 1 to figure 4. The nodes are connected by lines. The figures summarize the voltages, injections and flows that have been calculated using a power flow program. The data at each line show the power flows and not the losses.
A) In figure 1 the distributed generator is disconnected.

- Which node is the slack-node?
- What is the function of the tap-changer transformer?
- Explain the reasons for the voltage difference between node B, C and D.
- Is this a strong or a weak network?

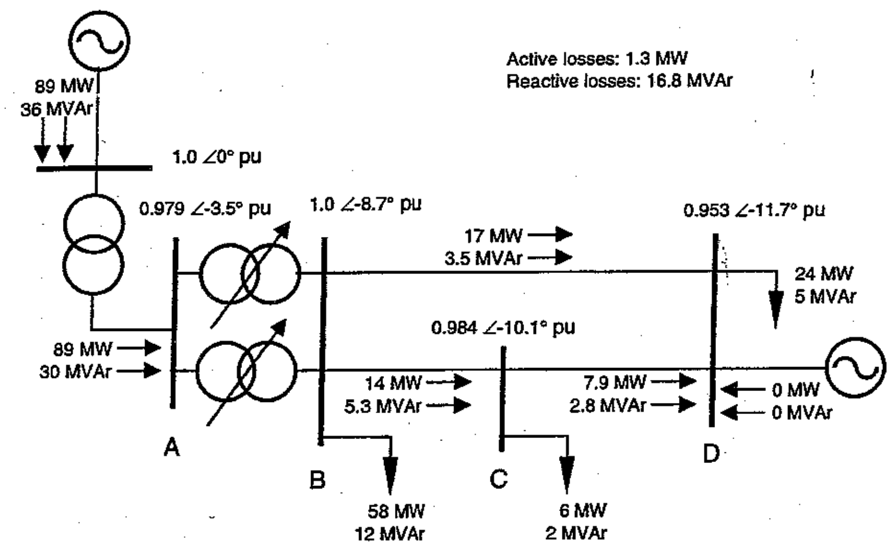


Fig.1:

B) A generator is connected at node D as shown in figure 2.

- Explain the changes in the voltage profile if the generator produces only active power.

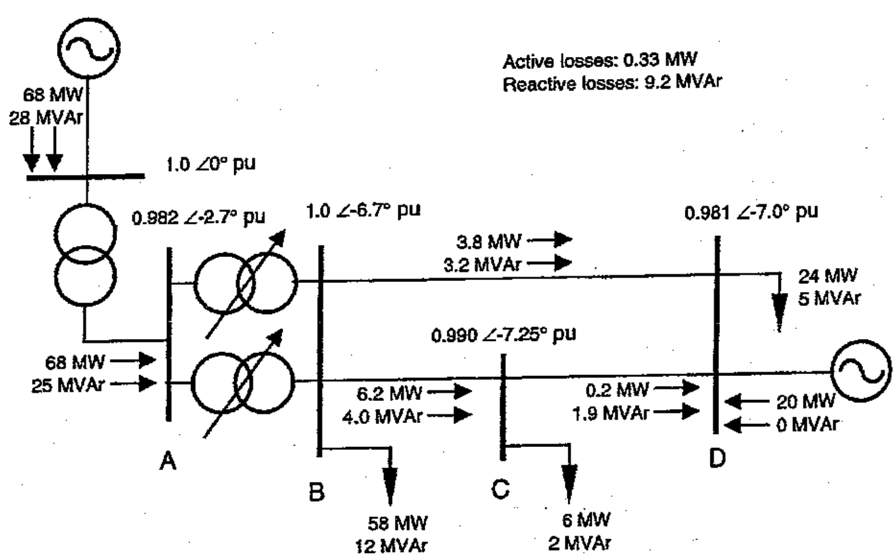


Fig.2:

C) In figure 3 the connected generator in D produces also reactive power.

- Which kind of generator is connected?
- Explain its influences on the voltage profile.

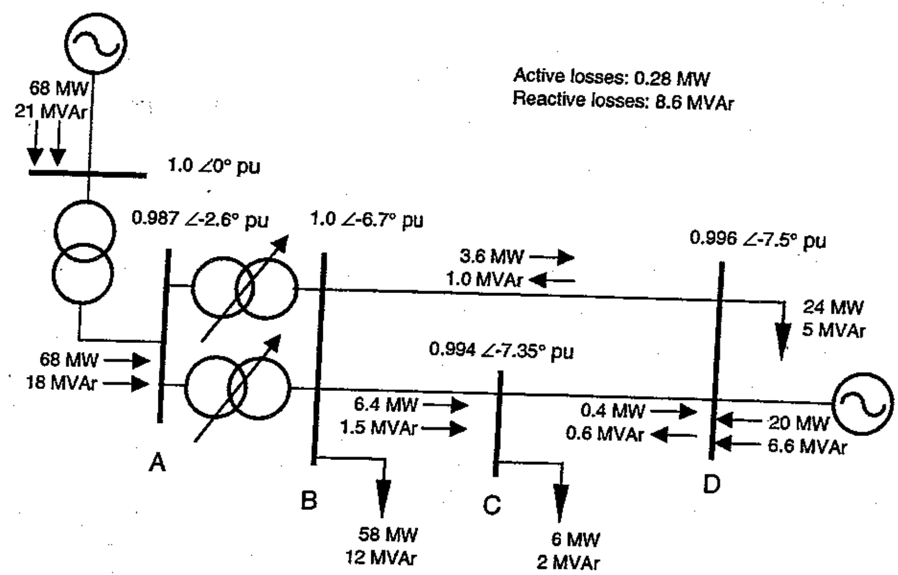


Fig.3:

D) An other generator is connected at node D as shown in figure 4.

- Explain again the influence on the voltage profile.
- How can this influence be reduced?

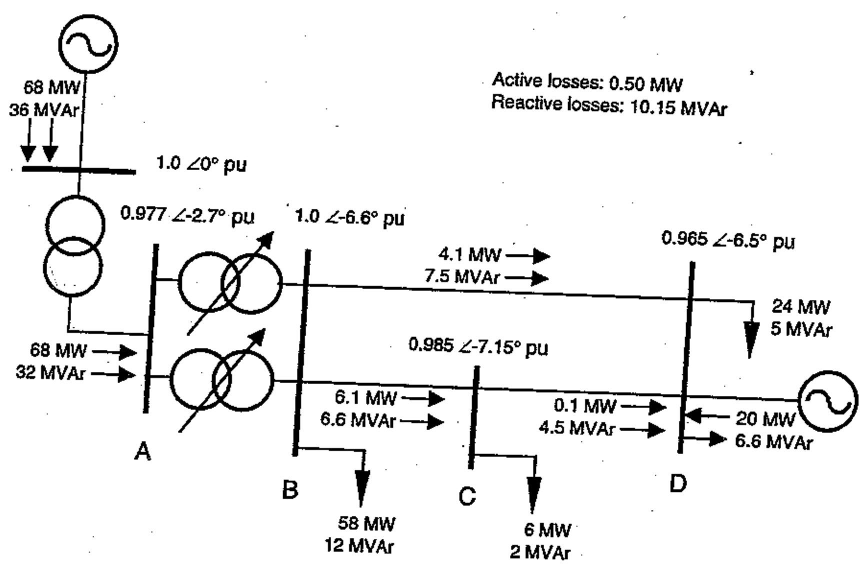
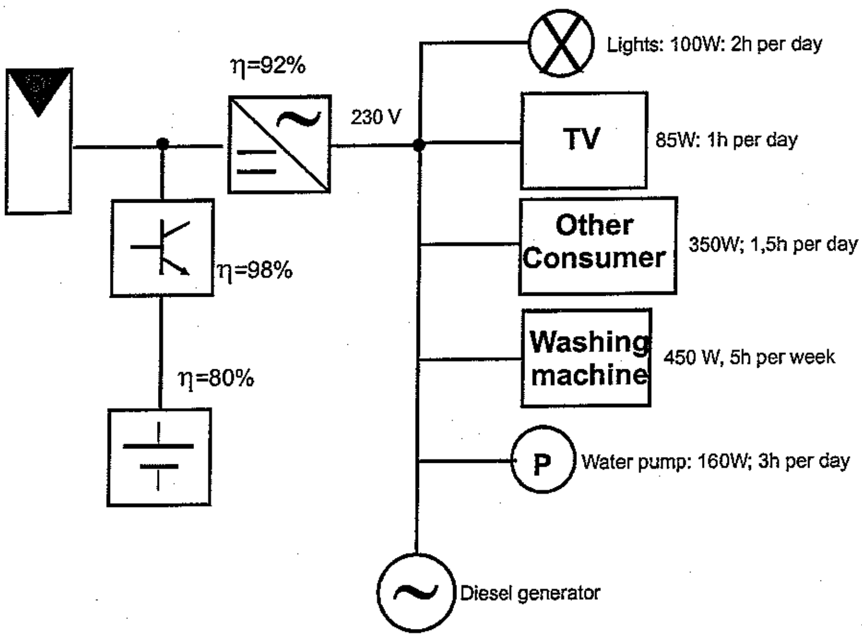


Fig. 4:

Problem 6: (2 points)
A farm house in a rural area of Spain is supplied by a diesel generator. The farmer will reduce the consumption of diesel and will use photovoltaics instead in the following system configuration.



He bought a PV generator of 150 W_{pk} and a battery system, which is adjusted to the size of the PV generator. All generated PV power will be consumed within the system.

Calculate the annual diesel consumption savings (%). Choose the optimal fixed solar panel inclination first.

The irradiation for the rural area is given in table 1. This table includes the inclination factor! Other loss factors can be taken from the lecture handouts.

MONTHLY MEAN OF DAILY IRRADIATION kWh/m^2

Month	0°	30°	50°
January	1.98	3.16	3.61
February	2.64	3.74	4.07
March	4.33	5.53	5.68
April	5.40	6.03	5.72
May	6.12	6.10	5.39
June	7.24	6.96	5.92
July	7.49	7.34	6.33
August	6.61	6.99	6.39
September	5.25	6.29	6.24
October	3.48	4.71	4.98
November	2.08	2.99	3.29
December	1.68	2.59	2.93

Table 1: Monthly values of the daily irradiation inclusive the inclination.