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DEE-24136 Distributed Energy Resources in Electricity Networks
Exam 18.12.2015

Sami Repo

Use of own programmable calculator is allowed in this exam.
Answers in English and Finnish are accepted.

Answer only to five questions.

1. Storage is predicted to have important role in the management of power system where variable renewable electricity production has a major role. Consider and describe your understanding of following storage related topics in future.
   A) What storage options you see the most promising for management of distributed generation connected to medium and low voltage networks?
   B) Explain the reason why storage is needed.
   C) How storage becomes profitable compared to traditional management solutions?

2. Protection blinding of medium voltage feeder is a serious consequence of distributed generation.
   A) Describe in what kind of circumstances protection blinding is possible.
   B) What is the reason behind the blinding effect?
   C) Describe also possible solutions for the problem.

3. Describe the situations when distributed generation has positive impacts on distribution network design. Provide explanations.

4. Consider the radial distribution network described in Figure 1.
   A) How the following terms (V_1, Z_1, n:1, Z_2, Z_3, Z_4, P_1, Q_1, P_2, Q_2, P_3, Q_3) effect on voltages of distribution network (V_2, V_3, V_4 and V_5)? V = voltage, Z = impedance, n:1 = tap ratio, P = active power, and Q = reactive power.
   B) Network hosting capacity for distributed generation might be enhanced by controlling voltage. How the traditional voltage control of distribution network utilizing tap changer might be enhanced in this case? Provide explanation.

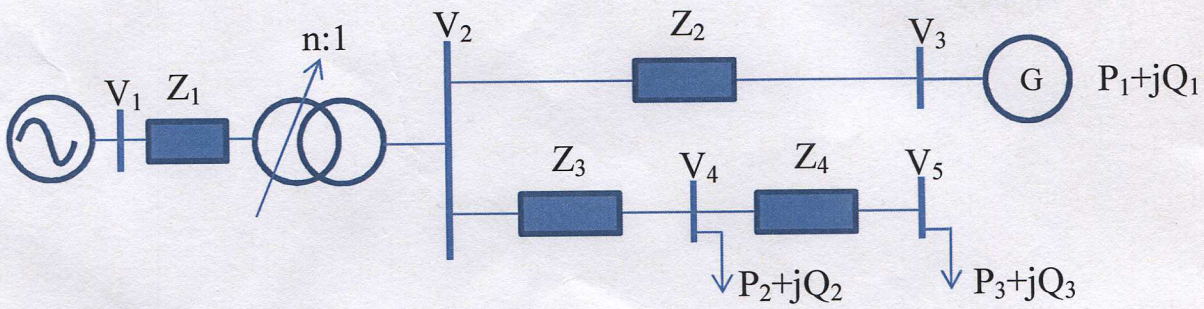

Figure 1.

5. Forecasting of wind power has important role in the market operation of producer.
   A) Explain shortly the main idea of large-scale wind power forecasting.
   B) What consequences forecasting error has for the producer?
   C) What factors influence on wind power forecasting error? How the error might be reduced?

6. Describe what kind of impacts large-scale wind power has for control and disturbance reserves. Explain why these happen.

7. Explain why the hosting capacity for distributed generation varies from 14 to 36 MW in the system of Figure 2. Describe the control of generation units (FG, NFG and RNFG) both in normal situation and during an outage of another transformer. Following assumptions are made: FG unit produce constant maximum output (14 MW), NFG unit is a wind farm (capacity factor 33 %, nominal output 12 MW), load is normally distributed (minimum 2 MW, average 7 MW and maximum 12 MW), and RNFG is fully controllable production unit (nominal output 10 MW). FG = Firm Generation. NFG = Non-Firm Generation. RNFG = Regulated Non-Firm Generation.

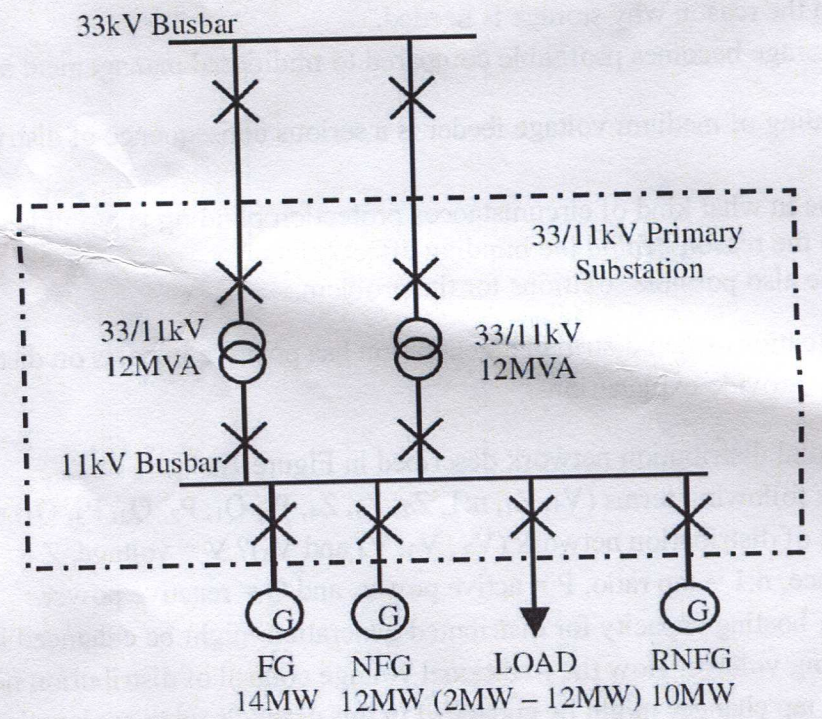

Figure 2.