DEE-24106 ELECTRIC POWER SYSTEMS

Enrique Acha and Sami Repo
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Attempt ALL questions

The numbers in square brackets in the right-hand margin indicate the marks allotted to the part of the question against which the mark is shown. These marks are for guidance only.

An electronic calculator may be used provided that it does not have a facility for either textual storage or display, or for graphical display.
If a calculator is used, intermediate steps in the calculation should be indicated.

Q1 (a) State what is the main objective of a power flow study. [1]

(b) State the three types of buses used in conventional power flow solutions and their specified and calculated variables. [2]

(c) For the circuit shown in Fig. 1 determine the nodal voltage solution using one iteration of the power flow Newton-Raphson method. Select bus 1 to be the slack bus, with a voltage magnitude of 1 p.u. and 0 phase angle. The voltage magnitude at bus 3 is also kept at 1 p.u. To start the iterative solution, assume 1 pu voltage magnitude and 0 phase angles in bus 2 and also assume a 0 phase angle at bus 3. [3]

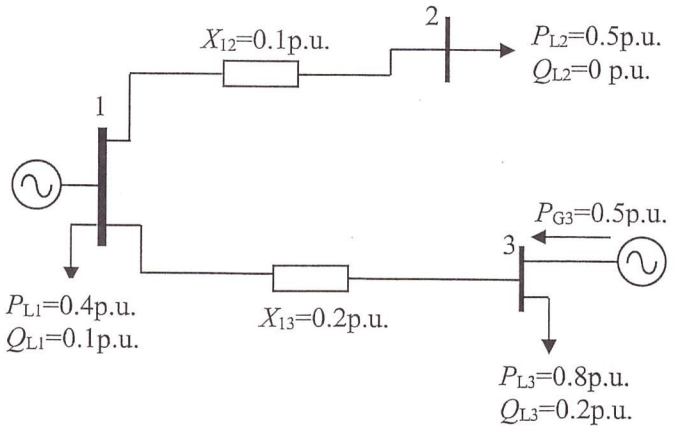

Fig. 1. Q1

Q2 The power circuit shown in Fig. 2 undergoes a three-phase-to-ground short-circuit fault in bus 3.

(a) Calculate the short-circuit fault current assuming a flat voltage profile of 1 p.u. in all buses just before the fault occurs and zero fault impedance, i.e. $Z_f = 0+j0$. [2]

(b) Determine the faulted nodal voltages in all buses, in sequence quantities and in phase quantities. [2]

(c) Calculate the current flows in the three transmission lines, two transformers and two generators in sequence quantities and in phase quantities. [2]

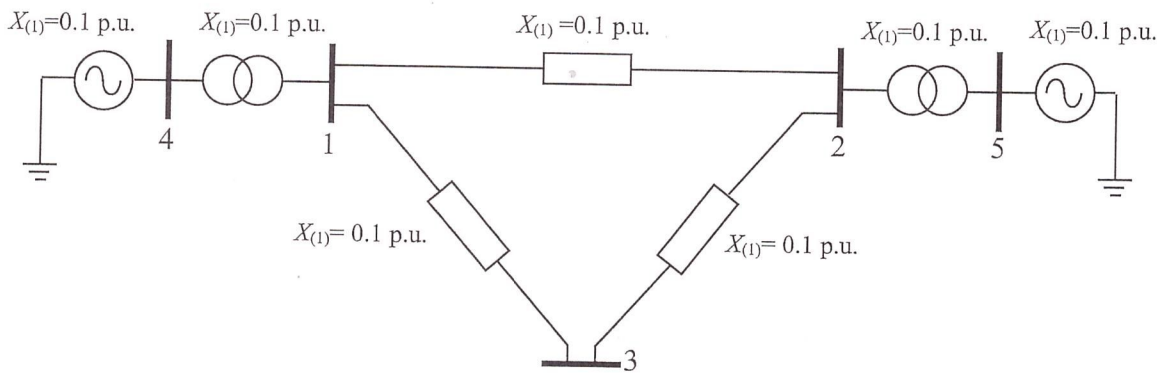

Fig. 2. Q2

Q3 (a)Explain with your own words what is (n-1) criteria and how it is used. [2]

(b) Price areas of day-ahead electricity market is a method for transmission network congestion management. Explain the basic idea of price areas and how it will resolve congestion in the network. [1]

(c) Extra high voltage transmission lines are typically over-compensated. Explain what over-compensation means, what consequences it has for power flow on transmission line, and how it may be mitigated. [2]

(d) Explain why rotor current limits of synchronous generators may endanger power system voltage stability. [1]

Q4 Figure 3 gives the power-angle curves of a power system where synchronous generator supplies power through two parallel lines into a stiff network. A fault occurs in the middle point of another line. The fault is successfully disconnected after some time by opening the circuit breakers at both ends of faulted line, at the same time. P = active power, δ = power angle, sub-indexes 0 and c corresponds to situations before the fault and at the time when the fault is disconnected, and sub-indexes e and m correspond to electrical and mechanical variables.

a) Estimate if cases A and B are stable based on the equal area criterion and figures. Draw the accelerating and decelerating areas and the maximum angle into both figures. Explain your estimations. [3]

b) Justify why power curves are different for conditions before fault, during fault and after fault. [1]

c) Determine a rough estimation of how the generator output power, rotating speed and power angle functions during different points of case A. Draw the necessary figures to explain your estimations. [2]

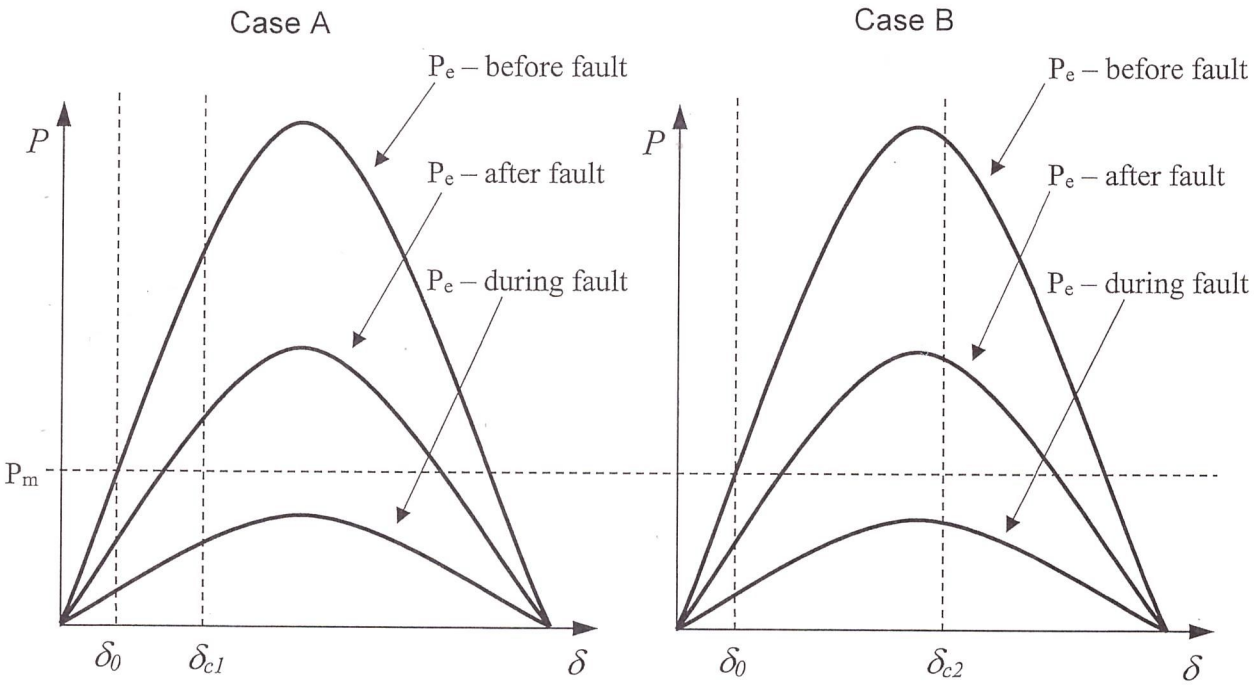

Fig. 3. Q4

Q5 Describe in chronological order what it is expected to happen in a well-functioning power system, during and immediately after the sudden disconnection of a large synchronous generator. [6]