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Gagan

DEE-24106 Electric power systems Angle stability Ex

1. A) A 60 Hz four pole turbogenerator rated 500 MVA, 22 kV has an inertia constant of H=7.5 MJ/MVA. Find $7.5 \times 500 = \cancel{1750}\ 3750\ MJ$
(a) the kinetic energy stored in the rotor at synchronous speed and
(b) the angular acceleration if the electrical power produced by the generator is 400MW and the mechanical input power to the generator is 552 MW (the rotational losses are neglected). $P_m - P_e = \frac{2GH}{2\pi f}\left(\frac{\partial^2 \delta}{\partial t^2}\right)$

B) If the acceleration calculated in A) remains constant for a period of 15 cycles, find the change in the angle δ in electrical degrees in that period and the speed in revolutions per minute at the end of 15 cycles. Assume that the generator is synchronized with a large system and has no accelerating torque before the 15-cycle period begins.

C) The generator is delivering rated megavolt-amperes at 0.8 power factor (lagging) when a fault reduces the electrical power output by 40%. Determine the accelerating torque in newton-meters at the time the fault occurs. Neglect losses and assume constant power input to the shaft.

2. A) The power delivered by a generator (on the left end of figure 1) through the depicted system is 0.8 per unit when both the terminal voltage of the machine ($V_t$) and the voltage of the infinite bus are 1.0 pu. Determine the power-angle equation for the system during the specified operating conditions.

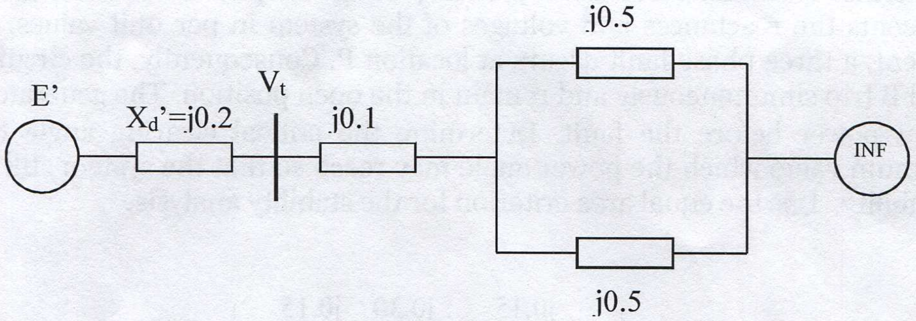
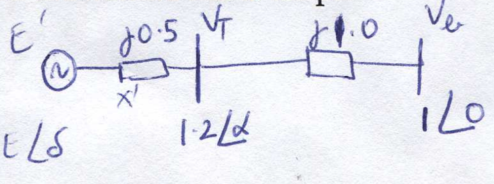


Figure 1.

B) If a three-phase fault occurs on the power system at a point on one of the transmission lines at a distance of 30% of the line length away from the sending-end terminal of the line, determine
(a) the power-angle equation during the fault and
(b) the swing equation. Assume the system is operating under the conditions specified in problem 2A when the fault occurs. Let H=5.0 MJ/MVA.

3. Find the steady state power transfer limit of a system consisting of a generator (equivalent reactance 0.50 pu) connected to an infinite bus through a series reactance of 1.0 pu. The terminal voltage of the generator is held at 1.20 pu and the voltage of the infinite bus is 1.0 pu.



~~$P = V_T V_e = 1.2 \times 1 \times \cos\alpha$~~

~~$= 1.2 \cos\alpha$~~

$P = \frac{E' V_e}{X_{eq}} = \frac{1.2 \times 1}{1.5} \times \sin = 0.8 \sin\alpha$

4. A generator is supplying power (P=176 MW, power factor $\cos\phi = 0{,}8_{ind}$) through a transformer and two transmission lines to a stiff system as depicted in Figure 2. At certain moment, a three phase fault occurs at location A (at the beginning of the line). The protection of this line is such that the circuit breakers at both ends of the line open at a time corresponding to power angle $\delta_1 = 50°$. Fast auto-reclosing of the faulted line is started at a time corresponding to power angle $\delta_2 = 85°$. However, the auto-reclosing is unsuccessful due to a permanent fault and the circuit breakers thus open again at a time corresponding to power angle $\delta_3 = 120°$. Is this system stable? Use the equal area criterion for the stability analysis. Losses are not taken into account.

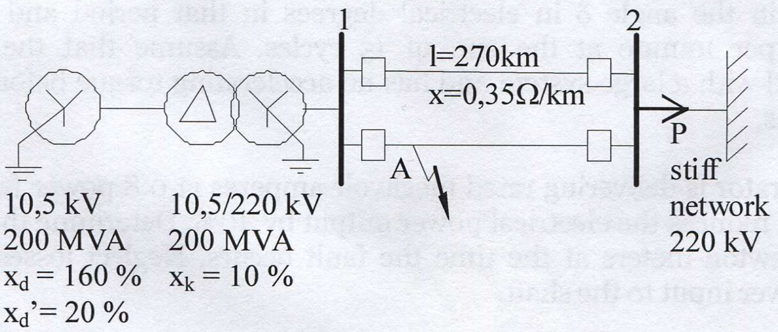


Figure 2.

5. A generator is connected to a stiff system (voltage 1.0 pu) via a double line. Figure 3 represents the reactances and voltages of the system in per unit values. At certain moment, a three phase fault occurs at location P. Consequently, the circuit breakers A and B trip simultaneously and remain in the open position. The generator supplies 1.0 pu power before the fault. Determine the critical clearing angle $\delta_{cr}$ i.e. the maximum value which the power angle may reach so that the system still maintains its stability. Use the equal area criterion for the stability analysis.

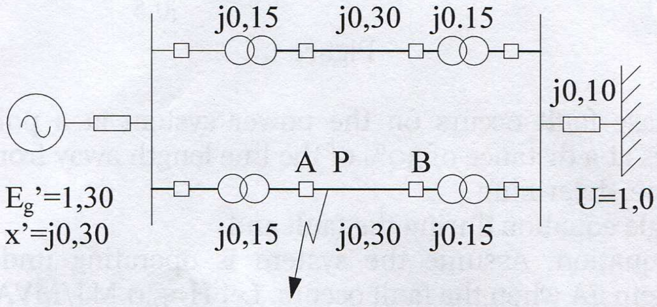


Figure 3.