Kafrelsheikh University - Faculty of Engineering – Electrical Engineering Dept. – FINAL EXAM			
Course	Advanced Control of Power Systems	Date	16-1-2020
Code	EPM4123	Time	3 Hours
Students	4th Year Electrical Power	Marks	90

This exam measures the ILOs: a.1, a.5, a.17, b.1, b.2, b.3, b.5, b.16, c.8, c.9, d.4

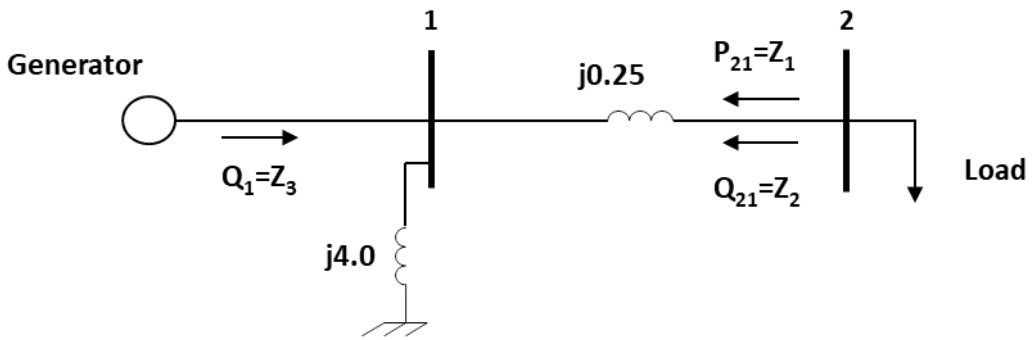
Answer the following THREE questions. Assume any missed data

Question 1 (30 Marks): In a power system, a phasor measurement unit (PMU) reports the measurements every 0.03333 second. The nominal voltage at PMU location has a magnitude of 1.05 pu and angle of 30°. The PMU measures: voltage, angle, frequency, real power and reactive power.

(a) Write an example of the time tag based on the reporting rate. (b) Based on the PMU measurements, explain how the power system engineer can recognize a disturbance. (c) How can you merge the internet of things (IoT) with PMU measurements in power system? Explain an example.

Question 2 (30 Marks): TWO PMUs are installed in the power system below at buses 1 and 2 to measure the quantities Z_1=0.9 pu, Z_2=0.3 pu, and Z_3=0.4 pu as shown in the Figure below. Take δ_1=0° as the reference angle. The three unknown state variables are $X_1=V_1$, $X_2=V_2$ and $X_3=\delta_2$. Consider the weights of the three measurements as 2×10^4, 2×10^4 and 10^4, respectively.

(a) Formulate the linearized equations for calculating the weighted least-squares estimates of the system states. (b) Compute (using THREE iterations) the weighted least-squares estimates of the state variables.



Question 3 (30 Marks): In the 60 Hz power system shown below: the system total reactance is 0.9 per unit, resistance is assumed to be negligible. The generator inertia constant is 1.1 MW.s/MVA. The damping torque coefficient is 11 pu torque/pu speed deviation. The rated speed is 377 electrical radians/second. The power flow analysis results the following: generator internal voltage has a magnitude of 1.1 pu and angle 11°. The infinite bus voltage has a magnitude of 1.01 pu and angle 0°. Consider that the generator speed and generator electrical power are the system outputs. Consider the generator mechanical torque as the system input.

(a) Derive the system state space model, b) Design an optimal controller such that the state weight matrix is the identity matrix and the input weight is ones. (c) Draw the poles of closed-loop and open-loop systems in the complex plane. (d) Reformulate the state space model to include the AVR and PSS models.