Machines and Power Electronics

1.0 Draw the magnitude plot (asymptotic bode) of the transfer function $2/(s^2 + 3s + 2)$.

2.0 If a dc motor with an emf constant of 2 V/(rad/s) is delivering a torque of 20 Nm, the armature current is _____ A.

3.0A second order closed loop system has a natural frequency of oscillations = 2 rad/sec and damping ratio = 0.707. Where are the closed loop poles located?

4.0 A mechanical system has a mass, spring and damper. To construct an electrical equivalent circuit, if force is represented by voltage and velocity by current, then the spring and damper may be represented by _____ and _____ respectively.

$$\frac{dx_1}{dt} = -x_1 - x_2$$

$$\frac{dx_2}{dt} = -2x_1 - 3x_2 + 5u(t)$$

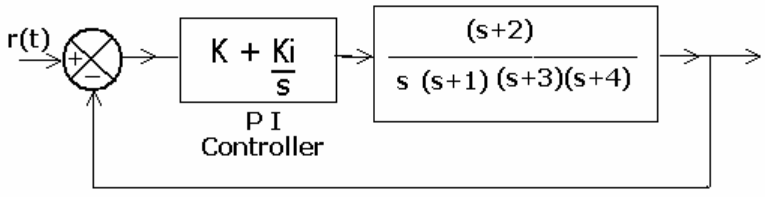
Ans: $X_1(s) / U(s) =$

5 Give the condition for critical stability from the Bode Plot.

6 Sketch the Pole-zero Positions for a Lead Network with one pole and one zero

7 A second order closed loop system has a natural frequency of oscillations = 2 rad/sec and damping ratio = 0.707. Where are the closed loop poles located?

8. For the control system shown, with a PI Controller, it is required to determine the ultimate value of **K** and the corresponding frequency **F** of oscillations at the out put, with **Ki** set at zero



Ans: K = F = (Hz)

9. A DC machine experiences flux saturation at 2 A field current. When operated as a generator running at 1000 rpm and 0.5 A field current, it generated 50 V. The output voltage at 2000 rpm and 1 A field current will be _____ V.

10. A load draws a current $i(t) = 4\sin(\omega t-30^o) + \sin(3\omega t+10^o) + 0.5\sin(5\omega t+20^o)$, when supplied by a voltage source $v(t) = 3125\sin(\omega t)$. The rms value of the current is _____ A and the power drawn by the load is _____ W.

Instrumentation and Control

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1. Draw the magnitude plot (asymptotic bode) of the transfer function $2/(s^2 + 3s + 2)$.

2. A mechanical system has a mass, spring and damper. To construct an electrical equivalent circuit, if force is represented by voltage and velocity by current, then the spring and damper may be represented by _____ and _____ respectively.

3. A 3 ½ digit digital voltmeter has a full scale of 200 mV. Draw a circuit that would convert the meter into a 20 W full scale ohm meter. Mark the values of all the circuit elements.

4.0 Give the condition for critical stability from the Bode Plot.
5.0 Sketch the Pole-zero Positions for a Lead Network with one pole and one zero

6.0 A second order closed loop system has a natural frequency of oscillations = 2 rad/sec and damping ratio = 0.707. Where are the closed loop poles located?

7.0 Determine the transfer function $X_1(s)/U(s)$ from the following equations:

$$\frac{dx_1}{dt} = -x_1 - x_2$$

$$\frac{dx_2}{dt} = -2x_1 - 3x_2 + 5u(t)$$

Ans: $X_1(s) / U(s) =$

8.0. The time response to an ideal impulse for a linear time invariant system was found to be: $f(t) = 10\, e^{-2t} \sin(5t)$. Write down the Laplace transform of the output of the same system (in the s-domain) when it is subjected to a Unit Step Input.

9.. In the circuit shown in Fig. Q12, an ideal switching transistor is used for ON/OFF operations The collector side load impedance is composed of two branches in parallel. Branch No1 is a

series combination of a **2 Ohm** resistance and a **10 milli H** inductor. Branch No.2 is a plain **3 ohm** resistance. Determine the current in the transistor, when it is ON. If it is suddenly switched off at t = 0, determine the magnitude of the voltage across the transistor, V_{AB} at $t = 0^+$

Ans: a) b)

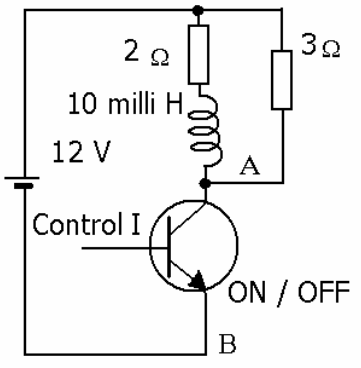

Fig. Q12

Power systems

1. Assuming the efficiency of Power Transmission to be constant, if the voltage is increased 'n' times, the size of the conductor would be
   (a) reduced to $1/n^2$ times that of the original.
   (b) increased to n^2 times that of the original.
   (c) reduced to $1/n$ times that of the original.
   (d) increased to n times that of the original.

2. Grading of the string of suspension type insulators is done such that:
   a) the top most unit has minimum capacitance and the bottom most has maximum capacitance
   b) the top most unit has maximum capacitance and the bottom most has minimum capacitance
   c) all units have equal capacitance
   d) none of the above

3. The steady state stability of the power system can be increased by
   (a) using machines of high impedance.
   (b) connecting lines in series.
   (c) connecting lines in parallel.
   (d) reducing the excitation of the machines.

4. The inductive interference between power and communication line can be minimized by
   (a) increasing the distance between the conductors.
   (b) Transposition of the power line.
   (c) Transposition of the communication line.
   (d) (b) and (c) both.

5. Given the following voltage and current expressions in single phase system.

$$v_s(t) = \sqrt{2} \times 230 \sin(\omega t)$$

$$i(t) = 2 + \sqrt{2} \times 10 \sin(\omega t - 60^0) + \sqrt{2} \times 3 \sin(3\omega t - 30^0)$$

Determine: Active power, P =
Reactive power, Q =
Power factor (pf) =

6. For the system given in the figure, which element with what value should be placed to make source power factor unity? For this condition what is current, ***I*** form source?

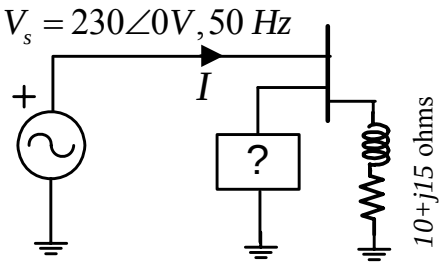

Fig. Q6

7. Find the machine angle δ, with the following assumptions: $|E| = 1.0$, $V\angle\theta = 1 + j0$, X_s, X_T, X_L are the synchronous, transformer and line reactance, respectively. All the values are in per units. (1 mark)

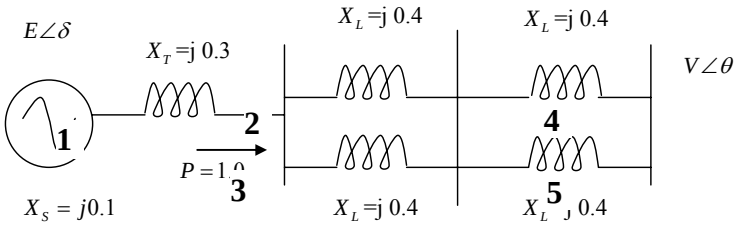

Fig. Q7

8. In Fig. Q11, find the real and reactive power flows in the transmission lines 1, 2 and 3 for the above problem.

9. A 100 MVA 33 kV 3-phase generator has a sub-transient reactance of 15%. Find the base value current and impedance. Find the actual value of the sub-transient reactance.

10. Circle the correct answer.

10.1 Insulation Breakdown –In a rod-plane air gap subjected to direct voltage, corona inception voltage for negative polarity on the rod of is lower / higher than that for positive polarity on rod and the break down voltage is lower / higher than that for positive polarity on rod due to positive / negative ion space charge.

ii) The intrinsic / thermal / erosion breakdown process of solid insulation is a fast / slow process and the corresponding breakdown voltage is the highest / lowest.

10.2 Generation of High Voltage -

i) Three 3-winding testing transformers are connected in cascade with the exciter, high voltage and coupler windings of each rated for 200kVA, 100kVA and 100kVA respectively. Without overloading any of the windings, the maximum output power possible will be 150 / 200 / 300 kVA decided by the exciter / high voltage / coupler winding of lower / upper most stage.

ii) Capacitive loading on an impulse generator primarily increases / decreases the front / tail time while Inductive loading decreases / increases the front / tail time, with respect to open circuit output.

10.3. High Voltage Measurement:

i) For impulse measurement with Resistance / Capacitance divider, matching impedance of the measuring cable is connected in series / shunt at divider / oscilloscope end.

ii) Capacitors used for PD / Tan delta measurement should be lossless / discharge free and are hence usually Gas filled / underrated.