Test Version B

Part 2: MAE 10 6 Midterm 2009

1. An oscilloscope is used to measure this:
a) voltage b) resistance c) current d) capacitance

2. An op amp is always described by which set of equations (choose the most complete set, and assume K > 0),?
a) $V_+=V_-$; $i_+=i_-=0$; $V=K(V_+-V_-)$
b) $V_+=V_-$; $i_+=i_-=0$; $V=-K(V_+-V_-)$
c) $V=K(V_+-V_-)$
d) $i_+=i_-=0$; $V=K(V_+-V_-)$
e) $i_+=i_-=0$

$V_+ = V_-$ only if connected with negative feedback

3. What is the period of a sine wave with a frequency equal to pi Hz?
a) 2*pi sec b) 1/(2*pi*pi) sec c) 2*pi*pi sec d) 1/pi sec

4. A band-pass filter attenuates:
a) high frequencies b) a band of frequencies c) low frequencies d) high and low frequencies

5. A first-order, low-pass filter causes a phase lag in a sinuosidal input. The amount of phase lag at a frequency much greater than the cut-off frequency is:
a) 90 deg b) 180 deg c) 45 degrees d) 70.7 deg e) 0 deg

6. The time constant of a first-order system tells when the output has gotten how far along the way to its final value?
a) 37% b) 10% c) 63% d) 90% e) 33%

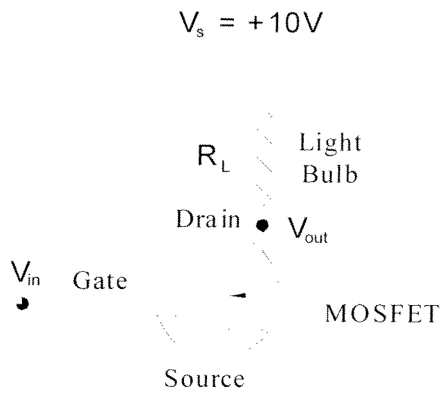
7. If you put a sine wave into a linear system, the output could be (chose the most complete answer):
a) bigger, smaller, or a constant, phase shifted, at a different frequency
b) smaller, phase shifted, and at the same frequency
c) bigger, smaller, and at a different frequency
d) bigger, smaller, or a constant, phase shifted, at the same frequency
e) bigger or smaller and at the same frequency

Note: If gain = 0 output will be a constant

For the next 7 problems, choose from these letters:
  a. Feedback controller advantage
  b. Feedback controller disadvantage
  c. Feedforward controller advantage
  d. Feedforward controller disadvantage

8. Requires an accurate model of the plant D
9. It has to allow an error to develop before it does anything B
10. Delay causes it to go unstable B
11. It only requires basic knowledge of the plant A
12. It can theoretically produce error-less control C
13. It requires a sensor B
14. It can cancel unexpected disturbances A

A circuit for controlling a light bulb with a MOSFET is shown below. The light bulb is modeled as a resistor. By changing the input gate voltage to the MOSFET, the light bulb can be turned on and off. A table of the MOSFET's drain/source resistance (like the one you generated in lab) is also shown.



V_{in} (volts)	R_{DS} (ohms)
0	100
1	100
2	90
3	80
3.4	75
3.6	41
3.9	4
4.2	0.1
5	0.01

15. Assume the light-bulb shines the brightest when the most current goes through it. It will shine the brightest when the input gate voltage (V_{in}) is:
a) 0 volts b) 5 volts c) 3.4 volts d) 1 volt e) 4.2 volts

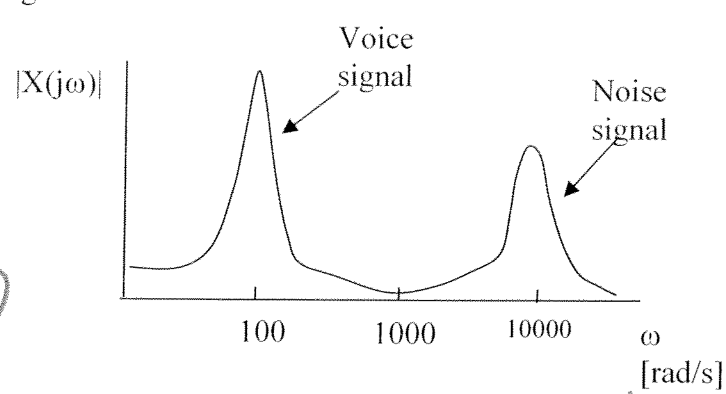
16. Assume R_L = 3996 ohms. Calculate V_{out} corresponding to an input gate voltage of 3.9 volts.
First significant digit of V_{out}:
16 a) 0 b) 1 c) 2 d) 3 e) 4
times 10 to the what power?
31 a) 1 b) 0 c) -1 d) -2 e) doesn't matter

$V_o = \left(\frac{4}{4+3996}\right) 10 = \frac{1}{1000} 10 = .01\,V = 1e^{-2} V$

17. Approximately how much current enters the gate?
First significant digit of ~~V_{out}~~ i_{in}:
17 a) 0 b) 1 c) 2 d) 3 e) 4
times 10 to the what power?
32 a) 1 b) 0 c) -1 d) -2 e) doesn't matter

Shown below is the frequency spectrum of a noisy speech signal. Design a RC low pass filter using your tool-box contents to get rid of the noise.

Toolbox Contents:
R = 1Ω, 10Ω, 100Ω, 1 KΩ
C = 1 pF, 0.1 μF, 1 μF

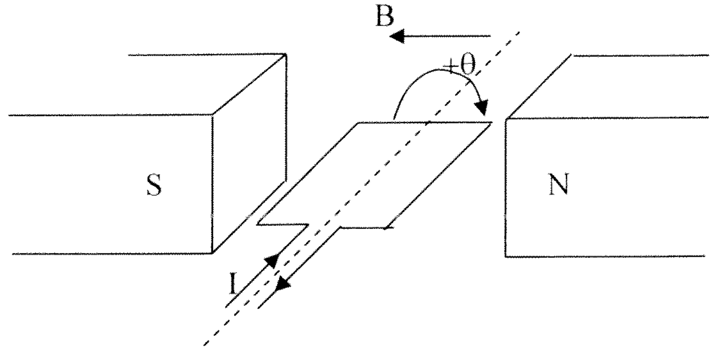


18. Value for R
a. 1Ω b. 10Ω c. 100Ω d. 1 KΩ

19. Value for C
a. 1.0 μF b. 0.1 μF c. 0.01 μF d. 0.001 μF

desire $\omega_c = 1000 = \frac{1}{RC}$
$RC = .001 = 1K\Omega \times 1e^{-6} F$

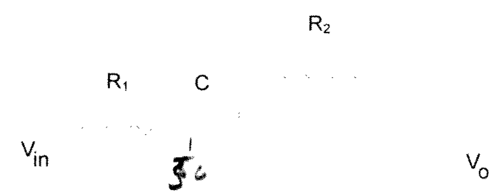
Shown below is a diagram of a DC brushed motor. Assume that the commutation stops working, such that current flows only in the direction shown.



20. At what angle θ will the armature come to rest? Assume the armature is initially at θ = 0° as shown when the commutation fails, and that positive θ is defined clockwise looking into the page, as shown.
a) 0 degrees
b) 180 degrees
c) 270 degrees
d) -90 degrees
e) 90 degrees

21. Which of the following is part of the commutation mechanism?
a) shaft b) armature c) brushes d) magnet e) coils

22. Assume the motor is working and the motor's torque constant and back EMF constant is B, internal resistance is R, and inductance L. Assume you hold the shaft fixed, and apply a voltage V. What is the final torque you will feel?
a) V/B b) BV/R c) L/R d) V/R
e) VR/B

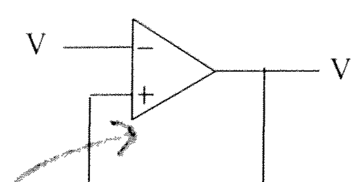


23. For the circuit shown to the right, assume R1 = R2 = 1 Kohm, and C = 0.5 μF. For a constant input V_{in} = 1 V, what is the magitude of V_o?
First significant digit of V_o:
a) 0 b) 1 c) 2 d) 3 e) 4
times 10 to the what power?
a) 1 b) 0 c)-1 d) -2 e) doesn't matter

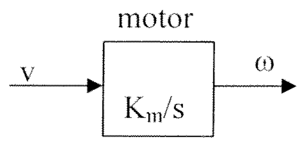
24. For the same circuit, for a very high frequency sinusoid with amplitude V_{in} = 1. what is V_o?
a) 0 b) -1 c) 1 d) 2 e) -2

25. times 10 to the what power?
a) 1 b) 0 c)-1 d) -2 e) doesn't matter

26. What is this circuit?
a) adder
b) useless
c) buffer
d) subtractor
e) amplifier

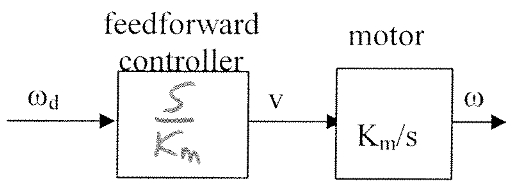


You want to control the speed of a motor. You are using a current amplifier with the motor, so the speed is related to the input voltage to the current amplifier by the following transfer function:



where v is the voltage input to the motor and ω is the angular velocity of the shaft and K_m is a constant.

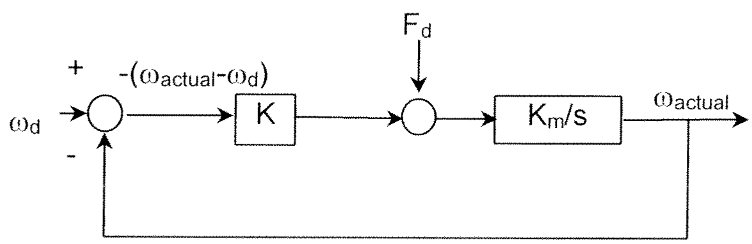
Shown below is a block diagram of an open-loop (i.e. feedforward) controller for the motor, where ω_d is the desired output of the motor. What transfer function should the controller box have to make the output equal the desired output?



27. Numerator of transfer function
   a) s b) v c) ω_d d) ω e) K_m

28. Denominator of transfer function
   a) s b) v c) ω_d d) ω e) K_m

One of the major benefits of feedback is its ability to cancel the effects of unmodeled "disturbances". Assume you build a feedback controller, but there is a disturbance force F_d affecting the motor:



You can view the effect of F_d on ω_{actual} as being described by a sort of filter.

29. What type of filter is it?
A. Band pass B. High pass C. Notch D. Motor E. Low pass

30. What values do you have to make big to eliminate the effect of the disturbance?
a) s b) K c) Km d) K or Km e) s or K

to see this: find transfer fcn.

$$\omega_a = \frac{K_m}{s}\left(F_d + K(\omega_d - \omega_a)\right)$$

$$\omega_a\left(1 + \frac{K_m K}{s}\right) = \frac{K K_m}{s}\omega_d + \frac{K_m}{s}F_d$$

$$\omega_a = \frac{K K_m}{s + K_m K}\omega_d + \frac{K_m}{s + K_m K}F_d$$

make big to cancel Fd