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八十三學年度研究所碩士班入學考試試題 所別：電機工程技術研究所 科目：工程數學

(1) Find the general solution of

$$xy' + 2x + y = 0 \qquad 10\%$$

(2) Find the solution of

$$y'' - 8y' + 16y = 8\ sin(2x) + 3e^{4x}; \qquad y(0) = \frac{2}{5},\ y'(0) = 1 \qquad 15\%$$

(3) Find the inverse Laplace transform of the function $ln(1 + \frac{4}{s^2})$ 10%

(4) An RL circuit and voltage source v(t) are shown in Figure 1, where R=4 ohm, L=1 henry and C=0.05 farad. Assume I(0)=0, find the current I(t)=? 10%

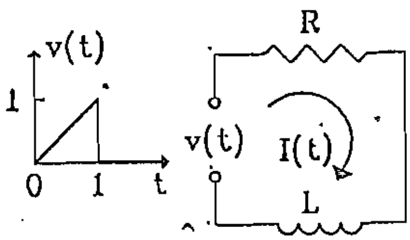

Figure 1

(5) (i) Find the eigenvalues and corresponding eigenvectors in Figure 2, where $R=\frac{2}{3}$ ohm, L=1 henry, C=0.5 farad.

(ii) Find the initial values of $i_1(0)$ =? and $V_c(0)$ =?, if $V_c(t) = 2e^{-2t}$ volt. 15%

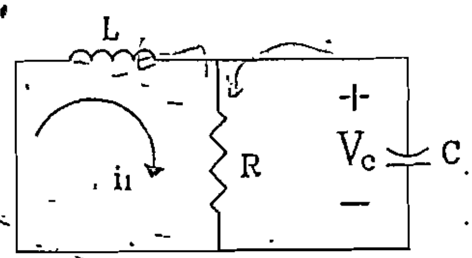

Figure 2

(6) (i) Find out what type of conic section the following quadratic form represents and transform it to principal axes.

(ii) Express $x^T = [x_1\ x_2]$ in terms of the new coordinate vector $y^T = [y_1\ y_2]$.

$$Q = 2x_1^2 + 2\sqrt{3}x_1x_2 + 4x_2^2 = 5 \qquad 15\%$$

(7) Find the Fourier series of the function

$$f(x) = x + \pi \quad \text{if } -\pi < x < \pi \quad \text{and} \quad f(x + 2\pi) = f(x) \qquad 10\%$$

(8) Find the Fourier cosine and sine integral of $f(x) = e^{-kx}$ 15%

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1. 負載潮流計算

一電力系統之單線圖如圖一所示，負載所消耗之複功率為 P+jQ

(1) 試將 P 與 Q 表為 $V_1, \delta_1, V_2, \delta_2$, Z 與 φ 的函數，即

$P = f(V_1, \delta_1, V_2, \delta_2, Z, \varphi)$ 及 $Q = g(V_1, \delta_1, V_2, \delta_2, Z, \varphi)$ (15%)

(2) 令 1 號匯流排為搖擺匯流排 (Swing Bus)，其電壓標么值 $V_1 = 1.0\angle 0°$ 且輸電線阻抗 $Z\angle\varphi$ 與負載所消耗之複功率 P+jQ 均為已知，試述如何利用牛頓-拉福森 (Newton-Raphson) 法解非線性方程組

$P = f(V_2, \delta_2)$ 及 $Q = g(V_2, \delta_2)$ (15%)

2. 暫態穩定度

圖二為一電力系統之單線圖，其中所有的數字均為電抗標么值。

(1) 無窮母線吸收之複功率為 S=1.0 + j0.2 p.u.，若斷路器 CB1 因不慎誤動作而開啓，試計算發電機轉子最大擺動角δ_3。 (15%)

(2) 若匯流排 c 發生三相短路，且斷路器 CB1 與 CB2 同時開啓以排除故障，試計算臨界清除角度 (critical clearing angle)。 (15%)

3. 感應電機

一額定 110 kW, 2300 V, 三相四極 60 Hz，Y接之鼠籠式感應電動機之試驗數據如下：

額定電壓與額定頻率下之空轉試驗

線電流 = 8.1 A　　三相功率 = 3025 W

在頻率為 15 Hz 時之堵轉試驗

線電壓 = 268 V　　線電流 = 52.5 A　　三相功率 = 19.2 kW

定子端子之間測得之電阻 = 2.35 Ω

若此電動機在額定電壓與頻率下運轉，計算轉差率為 2.85% 時，電動機之機械輸出功率。 (20%)

4. 同步電機

一凸極同步發電機之直軸、交軸飽和同步電抗分別為 X_d=1.8 p.u. 與 X_q= 1.65 p.u.，此發電機經一 X_e=1.65 p.u. 之電抗接至一無窮母線 (電壓 V_∞ =1.0 p.u.)。若此發電機輸出額定之伏安值，功因為 0.9 落後，計算其激磁電壓 (excitation voltage) 之標么值。 (20%)

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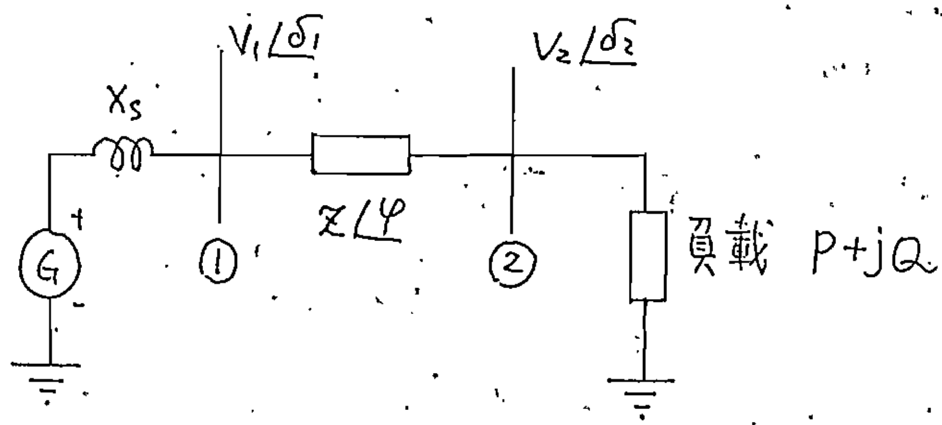

圖 一

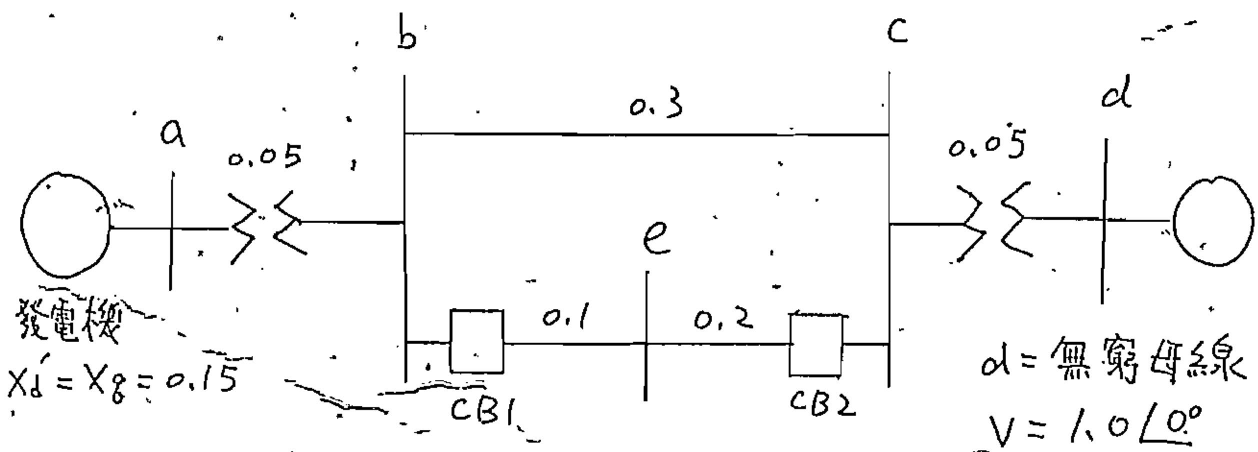

圖 二

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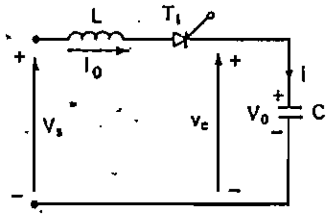
1. The circuit in Fig. 1 has $V_s = 600V$, $V_0 = 0V$, $L = 20\mu H$, $C = 50\mu F$, and $I_0 = 350A$. Determine (a) the peak capacitor voltage and current, and (b) the conduction time of thyristor T_1. 20%

Fig. 1



2. A resistive load is to be supplied from a phase-controlled rectifier. A step-down transformer connects the 480V (rms), 60Hz, source to the rectifier. Peak secondary voltage to the load is required to be 100V. The load resistance is 10Ω. The value of the phase control angle is 30°. 15%
   (a) For a bridge rectifier connected to the secondary windings, find the primary and secondary power factors.
   (b) For a full-wave rectifier with a center-tapped transformer, find the primary and secondary power factors.

3. A single-phase full converter is used to control the speed of a 5hp, 110V, 1200rpm, separately excited dc motor. The converter is connected to a single-phase 120V, 60Hz supply. The armature resistance is $R_a = 0.5\Omega$ and armature circuit inductance is $L_a = 5mH$. The motor voltage constant is $K\Phi = 0.09V/rpm$. Assume the motor current is ripple-free. 15%
   (a) The dc machine operates as a motor, runs at 1000rpm, and carries an armature current of 30A. Determine the firing angle α and the supply power factor.
   (b) A regenerative braking operation at 1000rpm is obtained by field reversal. The motor current is 30A. Determine the firing angle and the power fed back to the supply at 1000rpm.

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4. (15%) A buck - boost chopper supplies 100W at 50 V to a resistive load like that in Figure 4. from a 35-V source; T = 200 μs and L = 700 μH. Find: (a) the value of D (3%); (b) I_{min} and I_{max} (5%); (c) average switch current (5%); (d) average diode current (2%).

5. (15%) A single-phase ac voltage controller in Figure 5 has a resistive load of R = 15 Ω and the input voltage is V_s = 120 V, 60 Hz. The delay angle of thyristor T_1 is $\alpha = \pi/2$. Determine the (a) rms value of output voltage, V_o (5%); (b) input power factor, PF (5%); and (c) average input current (5%).

6. (20%) A single-phase bridge inverter in Figure 6 has a resistive load of R = 2Ω and the dc input voltage is V_s = 48 V. Determine the (a) rms output voltage at the fundamental frequency, V_1 (4%); (b) output power, P_o (4%); (c) average and peak currents of each transistor (4%); (d) total harmonic distortion, THD (4%); and (e) distortion factor, DF (4%).

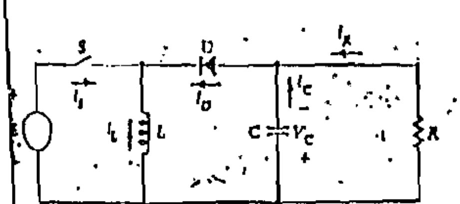

Figure 4.

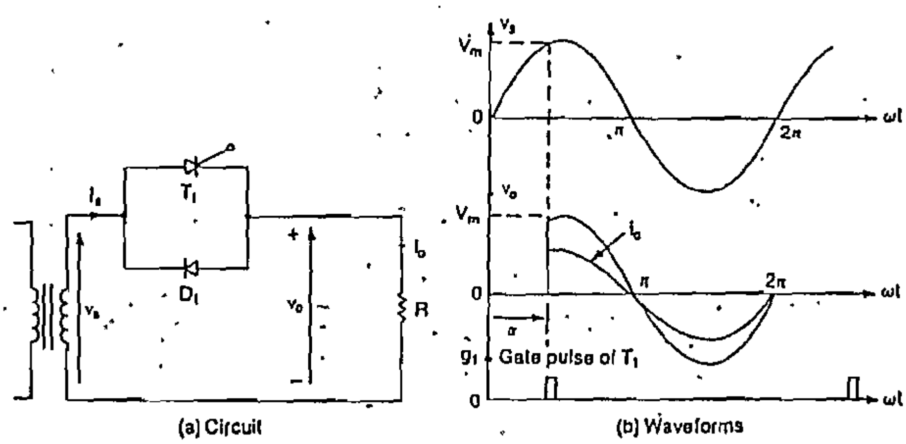

Figure 5.

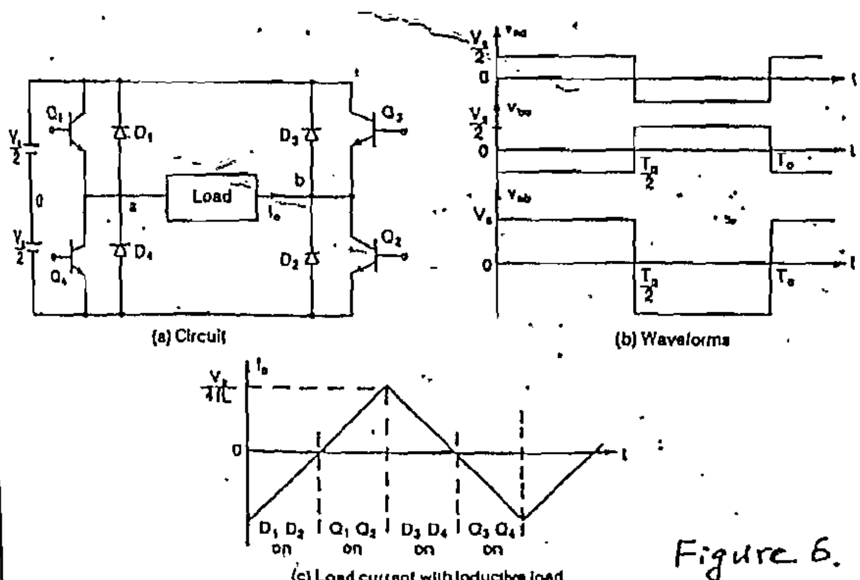

Figure 6.

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科目：電子學

1. For the circuit of Figure 1, find the voltage gain V_o/V_s, the input resistance R'_{if}, and the output resistance R'_{of}. The op amp has open loop gain $\mu = 10^4\ V/V$, $R_{id} = 100\ K\Omega$, $R_{icm} = \infty$, and $r_o = 1\ K\Omega$. (12 %)

2. Plot the transfer characteristic $V_o - V_i$ of the circuit in Figure 2. (8 %)

3. Find the logic function implemented by the circuit shown in Figure 3. (6 %)

4. The op-amp system of Figure 4 has a gain function that is

$$G(s) = \frac{10^3 * K}{(1 + s/10^4)^2}$$

$R = 1\ K\Omega$ and $C = 0.1\ \mu F$.

(a) Determine the closed-loop transfer function $V_o(s)/V_i(s)$. (7 %)

(b) Find the value of k above which the closed-loop system becomes unstable. (5 %)

5. Consider an NMOS invert with enhancement load having $V_{to} = 1\ V$, $(W/L)_1 = 4$, $(W/L)_2 = 1/4$, $\mu_n C_{OX} = 20\ \mu A/V^2$, $2\phi_f = 0.6\ V$, $\gamma = 0.5\ V^{1/2}$, and $V_{DD} = 5\ V$.

(a) Neglecting the body effect, find NM_H, and NM_L. (7 %)

(b) Taking the body effect into account, find the modified values of V_{OH} and NM_H. (5 %)

6. Write the transfer function of a second-order notch filter as shown in Figure 5 for which the dc gain is unity, the pole frequency is 10 rad/s, the pole Q is 0.5, and the transmission is zero at 100 rad/s. (10 %)

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7. A FET switch is connected with two load resistors as shown in Figure 6. The intent is to provide somewhat complementary signals at X and Y; that is, when one rises, the other falls. For the FET, $I_{DSS} = 10$ mA and $V_P = -2$V. For the diode, when conducting, $V_D = 0.7$V. When the diode is cut off, what are the voltages at X and Y? What voltage is required at A to ensure that the diode is barely cut off (diode voltage is zero)? What voltage on A is required to cause the JFET to cut off? What voltages on X and Y result? (15 %)

8. In the circuit of Figure 7 all devices are matched. Find the value of V_O. (10 %)

9. Write the transfer function for an amplifier having a gain of -100 at midband and a low-frequency response characterized by zeros at 1 and 10 rad/s (on the negative real axis) and poles at 5 and 100 rad/s. What is the dc gain of this amplifier? What is its 3-dB frequency? (15 %)

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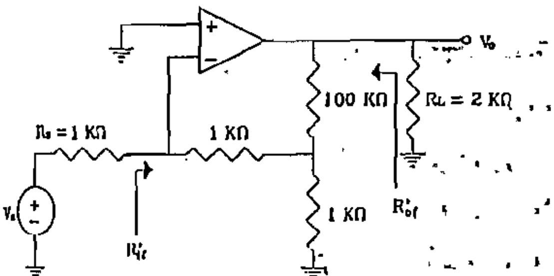


Figure 1

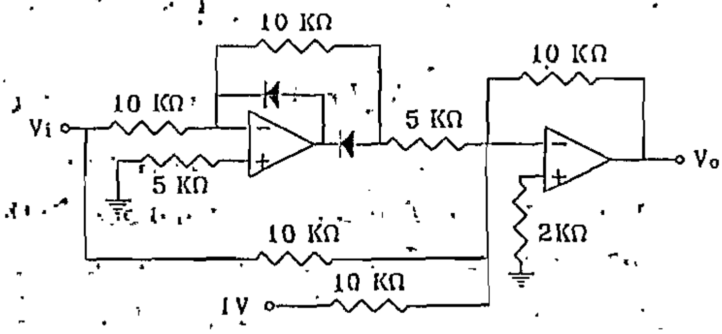


Figure 2

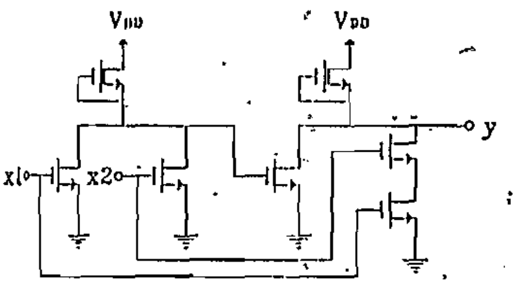


Figure 3

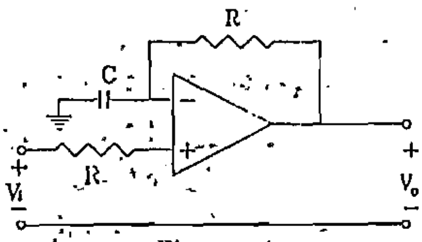
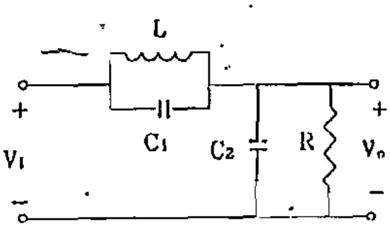


Figure 4



$C_1 + C_2 = C$

Notch: $\omega_n = \frac{1}{\sqrt{LC_1}}$

Figure 5

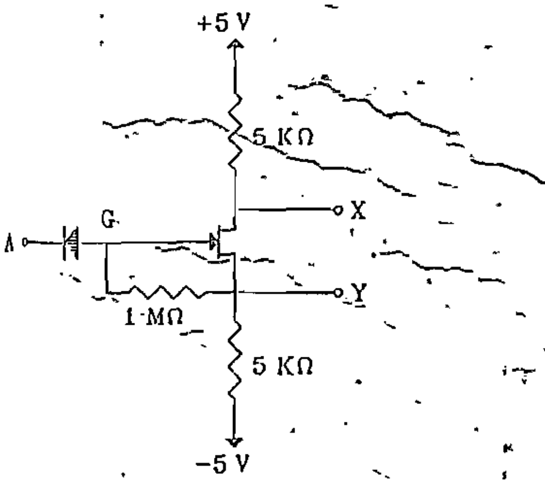


Figure 6

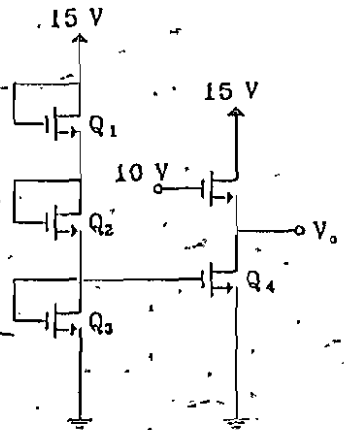


Figure 7

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(每題20分)

1. Find the transfer functions, $g_1(s) = x_1(s)/f(s)$ and $g_2(s) = x_2(s)/f(s)$, for the translational mechanical system shown in Fig. 1.

2. Consider a linear time–invariant system that is described by

$$\dot{x}(t) = Ax(t) + Bu(t)$$

where $x(t)$ is the state vector , $u(t)$ is the input vector, and A and B are matrices of appropriate dimensions. If a nonsingular transform $x = Py$ is used, then the above state equations are transformed into

$$\dot{y}(t) = P^{-1}APy(t) + P^{-1}Bu(t)$$

Show that the characteristic equation and the eigenvalues of A are the the same as those of $P^{-1}AP$.

3. Suppose that the input–output transfer function of a linear system is

$$\frac{C(s)}{U(s)} = \frac{s+1}{s^3+4s^2+5s+2}$$

(a) Write the state equations for the above system such that the system is state controllable.

(b) Write the state equations for the above system such that the system is state observable.

(c) Can you write the state equations such that the system is state controllable and observable? If not, explain why.

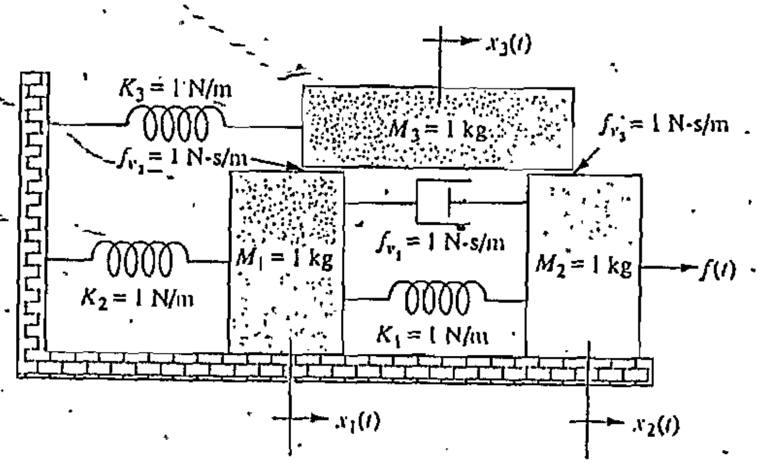

Fig. 1

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4. Find the input-output transfer function relation for the signal graph shown in Fig. 2.

(a) $\frac{y_6}{y_1}$

(b) $\frac{y_6}{y_2}$

5. Consider the transfer function of a linear process

$$G_p(s) = \frac{10}{s^2(s+25)}$$

Find a state feedback controller such that the closed-loop system satisfies the following specifications

(a) 20% overshoot.

(b) settling time = 4 seconds.

(c) zero steady-state error for a step input.

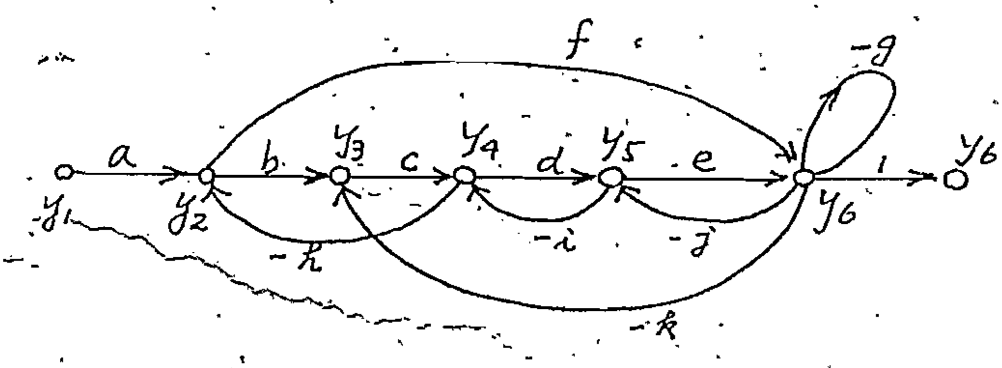

Fig. 2

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所別：電機工程技術研究所　科目：線性代數與機率

1. (15%) Find a unit vector perpendicular to the plane

$$4x+2y+4z=-7.$$

Justify your answer.

2. (15%) Solve the system of three linear equations in four unknowns:

$$\begin{aligned} 3.0x_1+2.0x_2+2.0x_3-5.0x_4&=8.0 \\ 0.6x_1+1.5x_2+1.5x_3-5.4x_4&=2.7 \\ 1.2x_1-0.3x_2-0.3x_3+2.4x_4&=2.1 \end{aligned}$$

Is there a unique solution? Explain your answer.

3. (20%) Let $\lambda_1,\lambda_2,\ldots,\lambda_n$ be the eigenvalues of a given matrix A. Prove that the inverse A^{-1} has the eigenvalues $1/\lambda_1, 1/\lambda_2, \ldots, 1/\lambda_n$.

4. (15%) Let X_1, X_2, and X_3 be three i.i.d. random variables and each has the pdf $f(x)=2x, 0<x<1$, zero elsewhere. Define Y to be the maximum of X_1, X_2, and X_3. Find and sketch the probability density and distribution functions, $f_Y(y)$ and $F_Y(y)$.

5. (20%) Two continuous random variables X and Y have the joint density given by $f(x,y)=ye^{-y(1+x)}u(x)u(y)$. Define the following two events $A=\{X>2\}$ and $B=\{Y>2\}$. Are A and B statistically independent?

6. (15%) Three fair coins are tossed. Let X denote the number of heads and Y the number of heads minus the number of tails. Find the joint probability distribution of X and Y.

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1. (15%) The nonlinear system decsribed by

$$y(t) = x(t) + x^2(t)$$

has an input signal with the lowpass spectrum

$$X(f) = \begin{cases} 1, & |f| < 20 \\ 0, & \text{otherwise} \end{cases}$$

Sketch the spectrum of the output, labeling all important frequencies and amplitudes.

2. (20%) Two signals $s_1(t)$ and $s_2(t)$, defined on $(0, T)$, are given by

$$s_1(t) = \begin{cases} A, & 0 < t < T/2 \\ -A, & T/2 < t < T \end{cases}$$

and

$$s_2(t) = \begin{cases} 0, & 0 < t < T/2 \\ A, & T/2 < t < T \end{cases}$$

Assume the signals are transmitted through an AWGN channel.

(a) (10%) Find the matched filter impulse response $h_o(t)$ for the two signals.

(b) (10%) Assume the two signals are equally probable. What is the optimum threshold that minimizes the average probability of error?

3. (15%) Three signals $s_1(t)$, $s_2(t)$, and $s_3(t)$ are given in Figure 1.

(a) (10%) Find a set of orthonormal basis functions corresponding to the signals shown below.

(b) (5%) Express s_1, s_2, and s_3 in terms of the orthonormal basis set found in part (a).

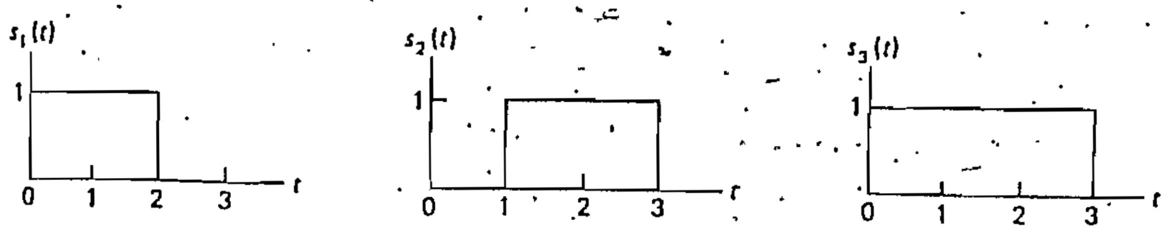

Figure 1

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4. (15%) The input to the RC circuit shown in Figure 2 is $A\cos(\omega_c t)$ plus white noise with double-sided power spectral density $N_0/2$. Compute the SNR at the filter output in terms of N_0, A, R, C, and ω_c.

(Note: $\int(1+x^2)^{-1}dx = \tan^{-1}x$)

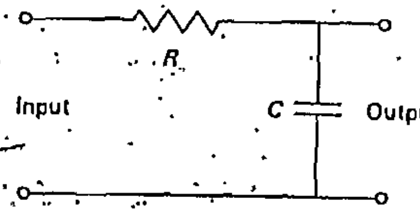

Figure 2

5. (15%) The input message signal to a modulator is $m(t)=2u(t)$, where $u(t)$ denotes the unit-step function. The unmodulated carrier waveform is $A_c\cos(\omega_c t)$.
   (a) (7%) Assume $m(t)$ is the input to a PM modulator with deviation constant $k_p=\pi/2$. Sketch the modulator output.
   (b) (8%) Sketch the modulator output if $m(t)$ is the input to an FM modulator with frequency deviation constant $k_f=\omega_c/2$.

6. (20%) A communication system transmits four possible signals at equal probability through an AWGN channel. Assume, using signal space concept, the four signals can be represented as the following two-dimensional vectors: (2,2), (0,2), (-2,2), (0,-2).

   (a) (10%) Draw the decision regions for each of the signals on a signal space.
   (b) (10%) What is the conditional error probability given that the signal (0,2) was transmitted?

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1. For the circuit of Figure 1, find the voltage gain V_o/V_s, the input resistance R'_{if}, and the output resistance R'_{of}. The op amp has open loop gain $\mu = 10^4\ V/V$, $R_{id} = 100\ K\Omega$, $R_{icm} = \infty$, and $r_o = 1\ K\Omega$. (12 %)

2. Plot the transfer characteristic $V_o - V_i$ of the circuit in Figure 2. (8 %)

3. Find the logic function implemented by the circuit shown in Figure 3. (6 %)

4. The op-amp system of Figure 4 has a gain function that is

$$G(s) = \frac{10^3 * K}{(1 + s/10^4)^2}$$

$R = 1\ K\Omega$ and $C = 0.1\ \mu F$.

(a) Determine the closed-loop transfer function $V_o(s)/V_i(s)$. (7 %)

(b) Find the value of k above which the closed-loop system becomes unstable. (5 %)

5. Consider an NMOS invert with enhancement load having $V_{to} = 1\ V$, $(W/L)_1 = 4$, $(W/L)_2 = 1/4$, $\mu_n C_{OX} = 20\ \mu A/V^2$, $2\phi_f = 0.6\ V$, $\gamma = 0.5\ V^{1/2}$, and $V_{DD} = 5\ V$.

(a) Neglecting the body effect, find NM_H, and NM_L. (7 %)

(b) Taking the body effect into account, find the modified values of V_{OH} and NM_H. (5 %)

6. Write the transfer function of a second-order notch filter as shown in Figure 5 for which the dc gain is unity, the pole frequency is 10 rad/s, the pole Q is 0.5, and the transmission is zero at 100 rad/s. (10 %)

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7. A FET switch is connected with two load resistors as shown in Figure 6. The intent is to provide somewhat complementary signals at X and Y; that is, when one rises, the other falls. For the FET, $I_{DSS} = 10$ mA and $V_P = -2$V. For the diode, when conducting, $V_D = 0.7$V. When the diode is cut off, what are the voltages at X and Y? What voltage is required at A to ensure that the diode is barely cut off (diode voltage is zero)? What voltage on A is required to cause the JFET to cut off? What voltages on X and Y result? (15 %)

8. In the circuit of Figure 7 all devices are matched. Find the value of V_O. (10 %)

9. Write the transfer function for an amplifier having a gain of -100 at midband and a low-frequency response characterized by zeros at 1 and 10 rad/s (on the negative real axis) and poles at 5 and 100 rad/s. What is the dc gain of this amplifier? What is its 3-dB frequency? (15 %)

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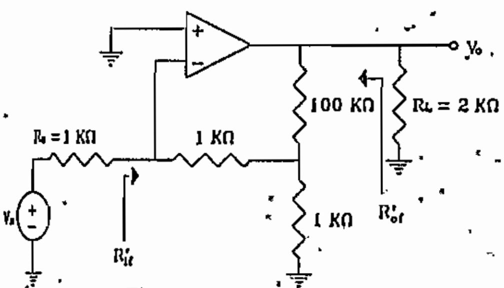


Figure 1

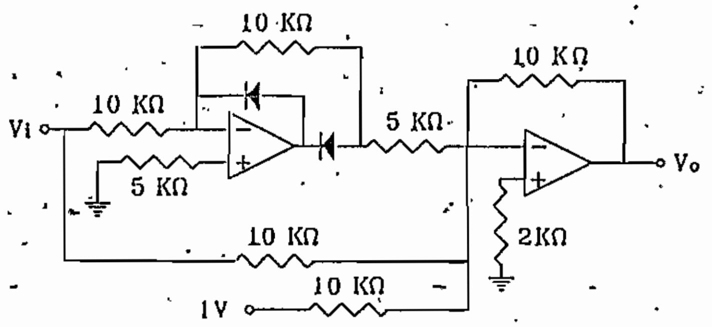


Figure 2

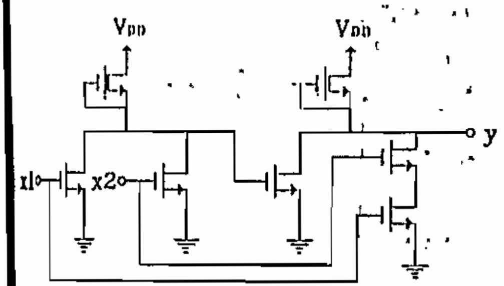


Figure 3

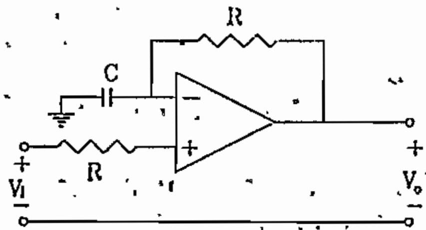
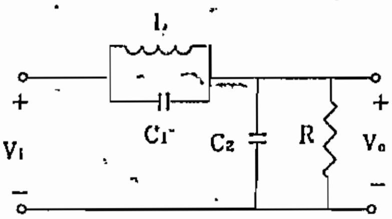


Figure 4



$C_1 + C_2 = C$

Notch: $\omega_n = \frac{1}{\sqrt{LC_1}}$

Figure 5

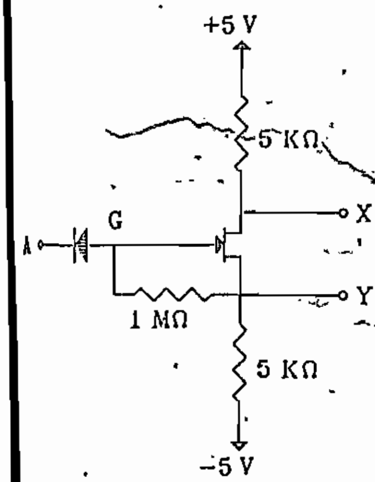


Figure 6

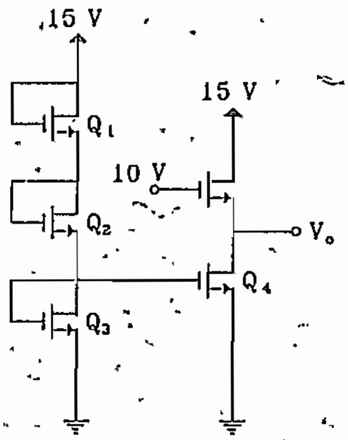


Figure 7