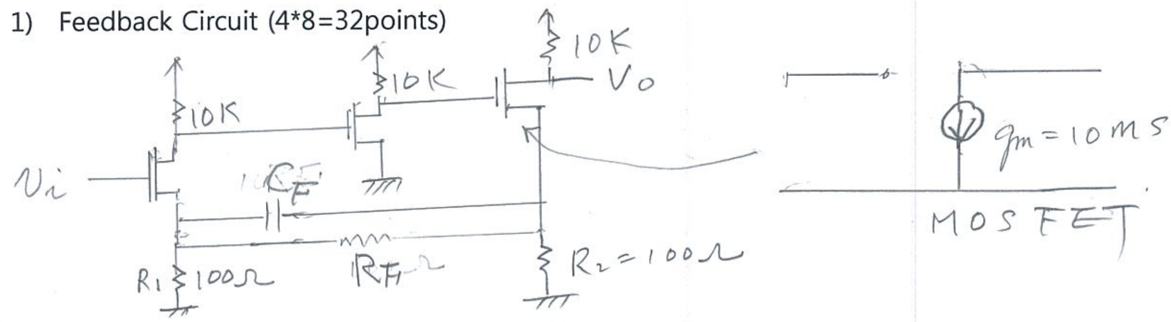
2011 QE Problem for Electronic Circuit (2011. 8. 10)

1) Feedback Circuit (4*8=32points)



a) Calculate open circuit gain of A_{open} , ß, and A_{close}

b) Calculate Z_{in} and Z_{out}

c) Calculate poles of the feedback circuit and describe the transient responses according to the pole locations (positive, negative and zero real parts)

d) Describe the oscillation criterion (Barkhausen oscillation criterion) of this feedback circuit

2) Design Chebyshev low pass Filter with 10MHz band with 0.5dB ripple, and 20dB decade attenuation after the pass-band (3*6=18 points)

a) Determine the minimum order of the filter

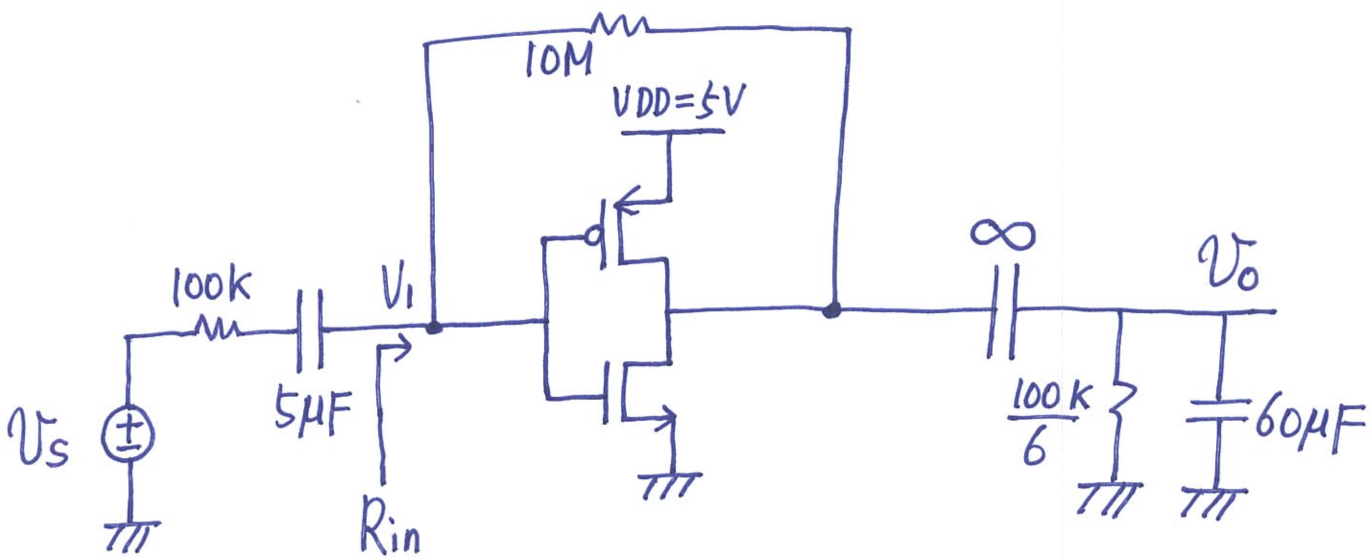
b) Determine the poles of the filter

c) Realize the filter using RLC components

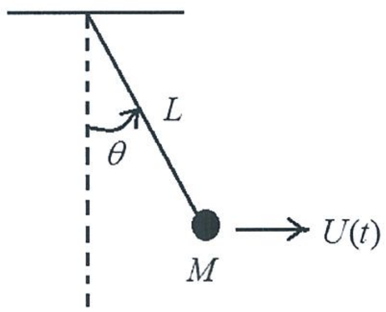
[3] 다음에 대해 간략하게 답하시오. (30점)

(1) 등가회로에 Dependent source(VCVS,VCCS,CCVS,CCCS)을 사용하는 이유
(2) 라플라스 변환(Laplace transform)을 사용하는 이유
(3) Diode의 대표적인 전기적 성질 한 가지
(4) OP amp 회로에서 virtual ground가 성립하기 위한 조건?
(5) Ideal voltage source와 ideal current source의 출력저항 값
(6) BJT의 forward active 영역 동작이란 무엇인가? 또 이 때 전류 사이에 어떤 관계식이 성립하는가?
(7) Common source, Common gate, CC (common collector) 증폭기가 각각 전압증폭기(V->V), 전류증폭기(I->I), transconductance amp(V->I) 중에서 어디에 적합한가?
(8) 오실로스코프에서 AC coupling이란 무엇인가? 이 때 사용되는 소자값은 관찰하는 신호주파수 f에 비해 어떤 조건을 만족해야 하는가? 단, 오실로스코프의 입력저항은 10메가옴.
(9) 밀러 정리 (Miller theorem)
(10) CMOS AOI (and or inverter) 회로를 트랜지스터로 그리시오. Y = .inv. ((A .and. B) .or. C)

[4] CMOS inverter를 증폭기로 사용하는 회로 (VDD=5V, VTH=1V(NMOS), -1V(PMOS), KP(u Cox W/L) = 4(NMOS), 1(PMOS) mA/ V^2) (20점)
(1) 입력전압 Vs(t)=0 일 때, V1 전압과 VDD에서 공급하는 power?
(2) 소신호 입력저항 Rin 값을 구하시오.
(3) 전압이득 전달함수 Av(s) = Vo(s) / Vs(s) 식을 구하시오.
(4) Steady state에서 Vs(t) = 0.01 sin(t) 일 때 출력 Vo(t) 식을 구하시오.



1. Consider a simple pendulum shown below.



Here U(t) is an external force.

a) Find the nonlinear differential equation that describes the motion of the pendulum.

b) Find the state equation.

c) Can you find the transfer function of the system? If not, specifically explain why.

2. Given the loop transfer function of a closed-loop control system with a pure time delay,

$$L(s) = L_1(s)e^{-Ts} = \frac{e^{-Ts}}{s(s+1)(s+2)}$$

a) Sketch the Nyquist plot of $L(s)$ when T=0.

b) Find the marginal value of time delay T so that the system is stable.

제어선택 2011. 8. 10

1. 제어시스템 설계 시 고려해야 할 사항 (설계사양, design objectives) 기술하시오.(20)
2. 선형시불변 (linear time-invariant) 시스템에서 다음 용어의 정의를 정확히 기술하시오.(10)
   완전가제어 (completely controllable) 완전가관측 (completely observable)
3. $g(t)$는 단일입출력(single input single output) 선형시불변 시스템의 impulse응답이다. 시스템이 BIBO(bounded input bounded output) 안정하기 위한 필요충분 조건이
   $\int_0^{\infty} |g(t)|dt \le M < \infty$ 임을 보이시오. 여기서 M은 상수이다. (20)

전력전자 문제

1. (50 points)

1) Explain (or define) the power factor of the converter with harmonic current components. (10 points)
2) Derive the power factor for a series-connected resistor-inductor R-L circuit. If $\omega L = 0.75R$, then obtain the power factor. (15 points)
3) Explain the operation principle of the practical forward converter not having large voltage spikes due to the stored energy in the transformer core. (15 points)
4) Derive the voltage stress across the switch of the forward convert- ter during the off interval. (10 points)

<2011 DQE - Communications & Signal Processing > (2011. 8. 10)

1. (40 points)

Consider a uniformly distributed random variable Z, defined by

$$f_Z(z) = \begin{cases} \dfrac{1}{2\pi}, & 0 \le z \le 2\pi \\ 0, & otherwise \end{cases}$$

The two random variables X and Y are related to Z by $X = \sin(Z)$ and $Y = \cos(Z)$.

(a) Determine the probability density function of X.

(b) Determine the probability density function of Y.

(c) Are X and Y uncorrelated random variables? Why?

(d) Are X and Y statistically independent? Why?

2. (60 points)

Let $\{s_1(t),\ s_2(t)\}$ be a binary orthogonal frequency shift keying (FSK) signal set with signal energy E_s. The signal is transmitted over an AWGN channel with a two-sided power spectral density of $\frac{N_0}{2}$ with equal probability.

a) Write down one example of the signal set, i.e., specify $s_1(t)$ and $s_2(t)$.

b) Sketch the signal constellation and specify the basis for the example given in problem (a).

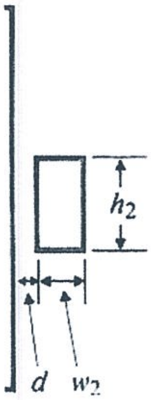
c) What is the average signal (symbol) error probability?

d) Let $\{s_i(t)\}_{i=1}^{M}$ be an equally likely M-ary FSK signal set transmitted over an AWGN channel with a two-sided power spectral density of $\frac{N_0}{2}$. Derive the Union bound on the average signal (symbol) error probability using results derived in (c).

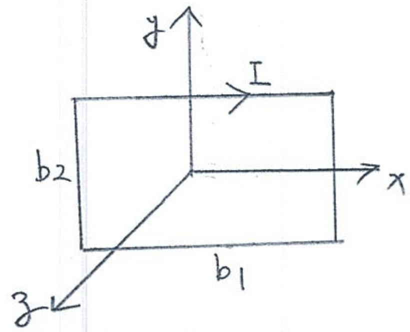
Electromagnetics and Microwaves

10 August 2011

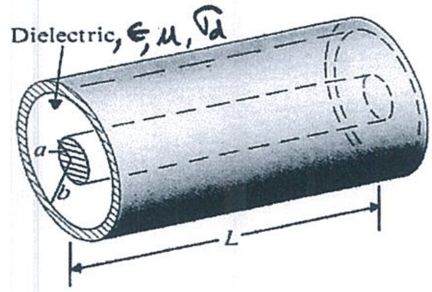
1. (10 pts) Find the mutual inductance between a very long straight wire and a conducting rectangular loop as shown below.



2. (10 pts) A rectangular loop in the xy-plane with sides b_1 and b_2 carrying a current I shown below lies in a uniform magnetic field $\vec{B}=\hat{x}5+\hat{y}6+\hat{z}7$.
   (a) Determine the magnetic dipole moment of the loop.
   (b) Determine the torque on the loop.
   (c) Determine the total force on the loop due to perpendicular component of $\vec{B}$.

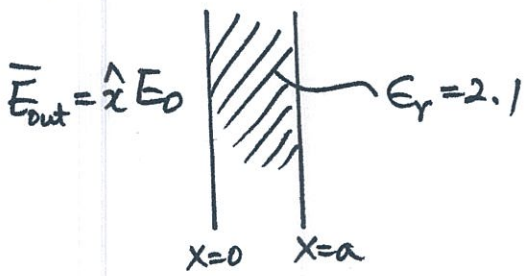


3. (20 pts) A coaxial cable consists of an inner conductor of radius a, and a very thin outer conductor of inner radius b. The dielectric has a nonzero conductivity of σ_d.



(a) Determine the capacitance per length of this cable.
(b) Determine the leakage resistance per length between the inner and outer conductors.
(c) Find the inductance per length of the cable, assuming that the current flows on the surface of the inner and outer conductors.

4. (10 pts) Teflon slab in the region $0 \le x \le a$, and free space elsewhere. Outside teflon, there is a uniform field of $\overrightarrow{E_{out}}=\hat{x}E_0$. Find $\vec{D}, \vec{E}$, and $\vec{P}$ inside teflon.



5. (10 pts) Show that one of Maxwell's four equations in differential form is not independent with the rest.

6. (10 pts) When does Brewster angle exist at an interface of two nonmagnetic media?

7. (10 pts) Given an impedance Z = R + j X, what procedure do we follow to find the admittance on a Smith chart?

8. (10 pts) A vacuum-filled rectangular waveguide made of a perfect conductor and having transverse dimensions a = 47.55 mm and b = 22.15 mm operates at a frequency 4.8 GHz in the dominant mode. Find the guide wavelength.

9. (10 pts) Design a five-element uniformly excited, equally spaced linear array for main beam maximum at 45 degrees from broadside. Each element is an isotropic radiator, and the spacing between adjacent elements is a half of a wavelength.

The end.

QE Semiconductor : Fundamentals (60 points) (2011. 8. 10)

[1] Explain and discuss the following statements.

(a) In a band completely filled with electrons, the net current is zero. [5 pt]

(b) If an electron is removed from a band, a net current can flow. [5 pt]

(c) The mean free time τ is given by $1/\tau = 1/\tau_A + 1/\tau_B$ if there are two independent scattering sources A and B with mean free times τ_A and τ_B, respectively. [10 pt]

[2] A Ge sample is lightly doped with donors $N_d = 5\times10^{13}$ cm^{-3}. Since N_d is comparable with the intrinsic carrier density of Ge $n_i = 2.5\times10^{13}$ cm^{-3}, we cannot use the simple approximation for the electron density given by $n \approx N_d$. Calculate the electron density in [cm^{-3}]. [20 pt]

[3] A p^+-n graded junction has a donor density $N_d(x) = Gx^{\alpha}$ $(x > 0)$ with permittivity ε and junction area A where the singularity at $x = 0$ for negative α can be neglected. Find the junction capacitance. [20 pt]

QE Semiconductor : Electronic devices (40 points)

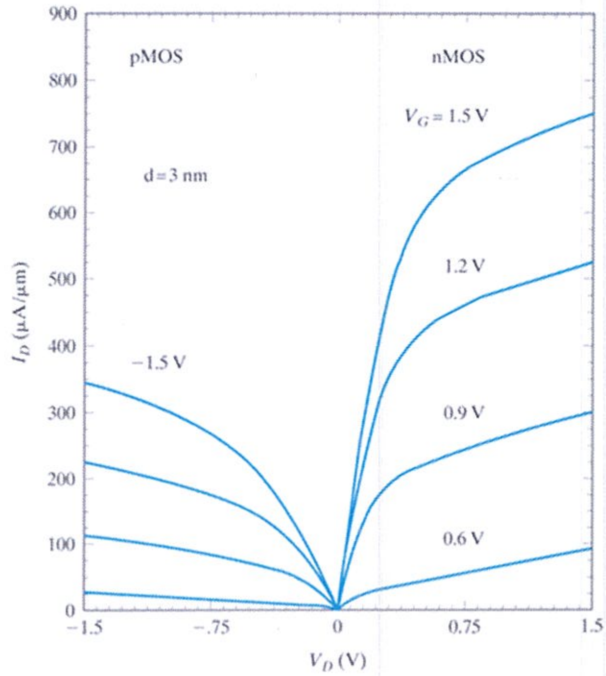


Figure 1

1. (MOSFET) Figure 1 shows experimental output characteristics of n- and p-MOSFETs.
   a) (7 pts) The curves exhibit almost equal spacing, indicating a linear dependence of I_D on V_G. What causes that behavior?
   b) (8 pts) We also observe that I_D increases somewhat with V_D in the saturation region. Explain the reason.
   c) (10 pts) Explain the gate-induced drain leakage (GIDL) using the energy band diagram.

2. (BJT) Consider a conventional pnp BJT with uniform doping. The emitter-base junction is forward biased and the base-collector junction is reverse biased.
   a) (5 pts) Qualitatively sketch the energy band diagram.
   b) (5 pts) Sketch the minority carrier concentrations in the emitter, base, and collector regions.
   c) (5 pts) lists all the causes contributing to the base and collector currents. Neglect the recombination-generation currents in the depletion region

QE Semiconductor : Optoelectronics (40 points)

[1] An electron with mass m is confined in an infinite quantum well (QW) ($0 < x < d$).

(a) Find the energy level E_n and wave function $\Psi_n(x)$ $(n = 1, 2, 3\cdots)$. [10 pt]

(b) According to the selection rule, the electron transition between the energy levels cannot occur if

$$\int_0^d dx\, \Psi_m^* \Psi_n = 0 .$$

Find the longest emission (or absorption) wavelength of the infinite QW. [10 pt]

[2] A semiconductor laser has a Fabry-Perot cavity where the cavity length is L, the mirror reflectivities are r_1 and r_2, and the internal loss is α. Find the threshold gain of the semiconductor laser. [10 pt]

[3] Explain and discuss the physical properties of graphenes and their applications for device and display applications. [10 pt]

2011. 8. 10

2011 Qualifying Exam: Mathematics

Caution!!!
Use separate answer books for Problems 1-5 (Math.-A) and 6-7 (Math.-B).

Math.-A

Problem 1. (10 points) Find the limits.

(a) $\lim_{x \to 0} \frac{8^x - 4^x}{2 - \sqrt{4 - x}}$

(b) $\lim_{x \to \frac{\pi}{2}} \frac{\tan(2x)}{x - \frac{\pi}{2}}$

Problem 2. (10 points) Differentiate

$$y = x^{x^n}.$$

Problem 3. (10 points) Find

$$\int \sin^3 x \cos^2 x \, dx.$$

Problem 4. (10 points) Find the solution by utilizing Laplace transformation:

$$y^{(2)}(t) + 2y^{(1)}(t) + y(t) = e^{-t},$$

where $y(0) = -2$ and $y^{(1)}(0) = 3$.

Problem 5. (10 points) Green's Formula says that

$$\oint_C \{Ldx + Mdy\} = \int\int_R \left(\frac{\partial M}{\partial x} - \frac{\partial L}{\partial y}\right) dxdy,$$

where C indicates the curve enclosing R, oriented counterclockwise. Let R be the region bounded by the triangle with vertices at $(0,0)$, $(1,0)$, and $(1,2)$. If we orient C in the counterclockwise direction, solve the following.

$$\oint_C \{xydx + x^2y^3dy\}$$

Caution!!!

Use separate answer books for Problems 1-5 (Math.-A) and 6-7 (Math.-B).

Math.-B

Problem 6. (25 points) Suppose that a linear system with input $\underline{x} \in \mathbb{R}^3$ and output $\underline{y} \in \mathbb{R}^3$ generates

$$\underline{y}_1 = \begin{bmatrix} 1 \\ 5 \\ 4 \end{bmatrix}, \quad \underline{y}_2 = \begin{bmatrix} 3 \\ 7 \\ 4 \end{bmatrix}, \quad \text{and} \quad \underline{y}_3 = \begin{bmatrix} 2 \\ 2 \\ -4 \end{bmatrix}$$

when it is driven by the inputs

$$\underline{x}_1 = \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix}, \quad \underline{x}_2 = \begin{bmatrix} 2 \\ 3 \\ 1 \end{bmatrix}, \quad \text{and} \quad \underline{x}_3 = \begin{bmatrix} 1 \\ 1 \\ -1 \end{bmatrix},$$

respectively. Answer the following questions.

(a) (5 points) Find a, b, c, d and e such that

$$a\underline{x}_1 + b\underline{x}_2 = \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix}, \quad c\underline{x}_1 + d\underline{x}_2 - 2\underline{x}_3 = \begin{bmatrix} 1 \\ -1 \\ 0 \end{bmatrix}, \quad \text{and} \quad \underline{x}_1 - \underline{x}_2 + e\underline{x}_3 = \begin{bmatrix} 0 \\ 0 \\ -1 \end{bmatrix}.$$

(b) (5 points) Find the output of the system when the input is

$$\underline{v}_1 = \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix}, \quad \underline{v}_2 = \begin{bmatrix} 1 \\ -1 \\ 0 \end{bmatrix}, \quad \text{and} \quad \underline{v}_3 = \begin{bmatrix} 0 \\ 0 \\ -1 \end{bmatrix},$$

respectively. (Hint. Use the result in (a).)

(c) (5 points) Find the inverse of

$$\begin{bmatrix} 1 & 1 & 0 \\ 1 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$$

(d) (5 points) Find the 2-dimensional subspace $S \in \mathbb{R}^3$ such that if the input to this system is in S then the output is a constant multiple of the input.

(e) (5 points) Find the general relation between the input $\underline{x}$ and the output $\underline{y}$ of this system. (Hint. Use the results in (b) and (c).)

Problem 7. (25 points) Answer the following questions.

(a) (5 points) Prove or disprove that the sum of two periodic continuous-time signals is in general a periodic signal.

(b) (10 points) When $h(t)$ be an absolutely integrable function, i.e., $\int_{-\infty}^{\infty} |h(t)|dt < \infty$. prove or disprove that

$$h(t) * \left\{ \sum_{k=-K}^{K} a_k \exp\left(\mathrm{j}\frac{2\pi kt}{T} \right) \right\}$$

is a periodic function.

(c) (10 points) When a continuous-time signal $x(t)$ is defined as

$$x(t) = \begin{cases} \frac{\sin \pi t}{\pi t}, & \text{for } t \neq 0 \\ 1, & \text{elsewhere,} \end{cases}$$

find the continuous-time Fourier transform of

$$y(t) = \{x(t)\}^2.$$

2011 PhD QE Problems (Computer Engineering) (2011. 8. 10)

1. Give an example of a logic expression, f(A,B,C,D), with 4 variables (A,B,C,D), minimize it with a **Karnaugh map,** and draw the circuit. (The trivial examples will be ignored.)
2. Explain the major differences between **von Neumann (Princeton) architecture** and **Harvard architecture**.
3. Explain the major differences between **real mode** and **protection mode**.
4. Explain the major differences between **processes** and **threads**.
5. Explain the major difference between **microprocessors** and **embedded processors**.
6. Show the gate-level logic design for a negative-edge-triggered D flip-flop. (*Hint: Start with an R-S latch, convert it an enabled R-S latch, then use this to derive a master-slave latch design.*)
7. Create and draw a timing diagram that shows the proper operation of a negative-edge-triggered D flip-flop.
8. Draw the state diagram and the logic design for a simple pedestrian crosswalk traffic light control system. If the light is red when the button is pressed, the light turns green for 2 clock cycles before turning back to red. If the light is green when the button is pressed, the light stays green for 1 more clock cycle before turning back to red.
9. Implement the following logic function using only two 4:1 multiplexers (both primed and nonprimed variables are available as primary inputs).

   $$f = a\, b\, c'\, d' + e'$$