2014-15

ANALOG CIRCUITS

ECE - 334

Time - Three Hours Full Marks - 70

Answer ***any five*** questions.

1. (a) Derive the expression of drain current (I_D) of an NMOS.

(b) Find g_m in terms of I_D, k, V_{GS}. If device size is fixed, how to increase g_m ? 6+8=14

2. (a) Draw the schematic of a CS amplifier. Draw its small signal equivalent circuit. What is the maximum voltage gain ? input values.

(b) For the circuit shown in Fig. 1, identify the amplifier configuration and determine its voltage gain (v_o/v_i), overall voltage gain (v_o/v_{sig}) and input impedance. 6+8=14

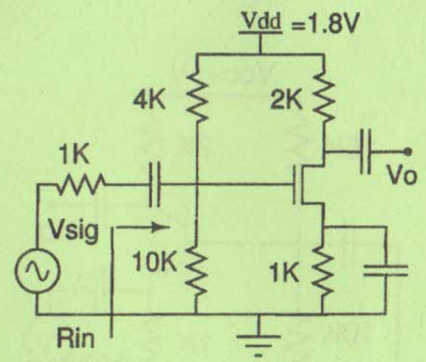

Figure 1 : of Q.2. Assume w/l = 20; $|V_T| = 0.5\ V$; $\mu C_{ox} = 100\mu\ A/V^2$

3. (a) Draw the symbol of an OpAmp and state its ideal characteristics. Also express the relationship between input and output.

(b) Using OpAmp, draw the circuit of a differential amplifier and differentiator and derive its transfer function.

6+8=14

4. (a) State the advantages of negative feedback. Show that, gain of an amplifier with feedback (A_f) is given

$$A_f = \frac{A_o}{1 + A_o \beta}$$

(b) A voltage amplifier has an open-loop voltage gain of –100 with input and output impedance equals 10K. A feedback network with 5% feedback is now connected to the amplifier. What is the voltage gain of the amplifier with feedback ? What will be in its input and output impedance ?

7+7=14

5. (a) Find the dc operating point of the BJT circuit shown in Fig. 2. Assume Silicon transistor with β = 100 and V_A = 40 V.

(b) If the transistor is replaced by a new transistor with β = 150 what will be new operating point ? Find its voltage gain.

6+8=14

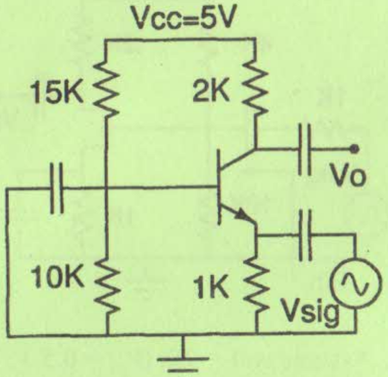

Figure 2 : of Q.5

6. For the transistors shown in Fig. 3,

(a) State the operating region of each transistor.

(b) Also find their drain/collector current.

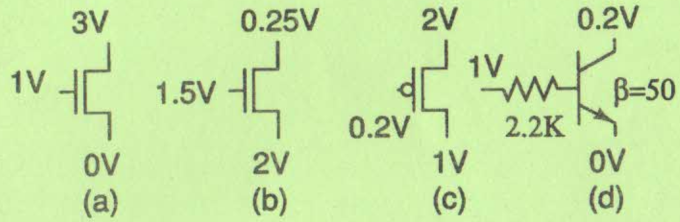

Figure 3: of Q.6. Assume w/l=10; Use device parameters of Fig. 1

7. (a) State Barkhausen's criteria of oscillation.

(b) Using OpAmp, draw the schematic of a Wien-Bridge Oscillator and find the condition of oscillation.

6+8=14

8. Write short notes on : 5+4+5=14

(a) Source-follower

(b) Threshold voltage of MOS

(c) BJT *vs.* MOS.

2014-15

DIGITAL SIGNAL PROCESSING

ECE 701

Full Marks : 70 *Time* : 3 hours

The figures in the margin indicate full marks.

Answer should be brief and to the point.

Answer any *five* questions.

1. (*a*) State the four basics steps of digital filter design. State the major sources of error in digital filters. State the advantages of Digital filters. 14

   (*b*) A low pass filter has the desired response as given below :

   $$H_d(e^{jw}) = e^{-j3w}; \text{for } 0 \le |w| \le \frac{\pi}{2}$$

   $$H_d(e^{jw}) = 0; \text{for } \frac{\pi}{2} \le |w| \le \pi$$

   Determine the filter coefficients h (n), for N=6 using Type-II frequency sampling method of designing FIR filter.

   (*c*) State the features of FIR and IIR filter.

2. (*a*) Derive the design parameters for Butterworth Analog Low Pass filter from the given specifications of a digital low pass filter. Design a digital Butterworth filter by first converting the given specifications of digital filter that satisfies the following constraint into analog filter and then convert it

into digital filter using bilinear transformation. Assume sampling time T = 1 sec. 14

$$0.8 \le \left|H\left(e^{jw}\right)\right| \le 1; for\ 0 \le w \le \pi/2$$

$$\left|H\left(e^{jw}\right)\right| \le 0.2\, for 3\pi/4 \le w \le \pi$$

(*b*) State the characteristics of the following analog low pass filters :

(*i*) Chebyshev Type -I filter and

(*ii*) Elliptic Filter.

3. (*a*) State 10 (ten) properties of Z-transform. 14

(*b*) Find analytically the Z transform of the function i) x(n) =n and ii) x(n) = $\cos(w_0 n)$.

(*c*) Prove the time multiplication property of Z-transform and Initial value theorem of Z transform.

4. (*a*) State the methods of finding the solution of any Discrete Time System. Find the solution of the following difference equation using any method, with initial conditions as

$$y(-1) = 4 \text{ and } y(-2) = 10y(n) - \tfrac{3}{2}y(n-1) + \tfrac{1}{2}y(n-2) = \left(\tfrac{1}{4}\right)^n$$

14

(*b*) Convert a non recursive system of (n+1) sample averager

$$y(n) = \frac{\sum_{k=0}^{k=n} x(k)}{(n+1)}$$, into a recursive system. Compare the hardware requirements to realize the non recursive and recursive system respectively.

5. (*a*) State the different structures that are available for implementation of IIR and FIR systems respectively.

For a DTS having $H(z) = 0.5 - 3z^{-1} + 5z^{-2} + 7z^{-3} + 7z^{-4} + 5z^{-5} - 3z^{-6} + 0.5z^{-7}$.

Implement the above system function using Direct Form –I structure. Write down the difference equation for the above system. Find the impulse response of the above system. Does the above system satisfy linear phase characteristics ? 14

(*b*) What do you mean by Linear Phase FIR filter ? State the types of Linear Phase FIR Filter. Derive an expression for **H(e^jw)** for FIR system, which satisfy the property of symmetric sequence i.e. h (n) =h (N-1-n) for N= Even integer, where N= number of samples, hence determine the phase and group delay of this system. Aslo identify the type of this FIR filter.

(*c*) State some important applications of DSP.

6. Write short notes on any *two* of the following : 7 + 7 = 14

(*a*) Obtain an expression for the quantization error due to signal quantization in

(*i*) FIR filter as 3-sample averager :

$$y(n) = \frac{1}{3}[x(n) + x(n-1) + x(n-2)] \text{ and}$$

(*ii*) 1st order IIR filter : y (n) = ay (n-1) + x (n).

(*b*) Signal flow graph.

(*c*) Jury's stabvility criteria for a discrete time system.

(*d*) Type-II State Space representation of a discrete time system.

7. (*a*) A low pass FIR filter is to be designed with the following desired frequency response :

$H_d(e^{jw}) = e^{-j5w}, -\pi/3 \le w \le \pi/3 = 0$, otherwise. Determine the filter coefficients using Bartlett window function assuming N=4. State the advantages and disadvantages of windows method of designing FIR filter. 14

(*b*) Write a matlab program to design a band pass FIR filter of order 15 using Blackman window function having a lower and upper cut off frequencies of 1200 Hz and 2500 Hz respectively with a sampling frequency of 4800 Hz.

(*c*) A digital filter with 3 dB bandwidth of 0.25 is to be designed from an analog filter whose systems function $H(s) = \frac{\Omega_c}{S+\Omega_c}$. Use bilinear transformation and assume sampling time T = 1 sec. What do you mean by Analog Frequency Band Transformation ? Write down the four transform relations for Analog Frequency band transformation.

8. (*a*) For a discrete time system if input x(n) = [1 2 3 4] for $0 \le n \le 3$ and impulse response of the system is h(n)=[1 1 3 5] for $0 \le n \le 3$. Find the circular convolution of the above two sequence using graphical method. Under what condition one can find the response of the above discrete time system using circular convolution between x(n) and h(n) i.e. using the concept of DFT and IDFT. 14

(*b*) State few important applications of DFT. What do you mean by decimation in time FFT (DIT-FFT) algorithm ? Derive expressions for $X_{10}(k)$, $X_{11}(k)$, $X_{10}(k+N/2)$ and $X_{11}(k+N/2)$ for determining N-point DFT of x (n) considering decimation in time FFT algorithm. How FFT algorithm be used to find IDFT of X(K) to find x (n) ? Given the four samples of X(K), as X(k)={(20) (-4+4j) (-4) (-4-4j)}, find x (n) using DIF – FFT algorithm. Compare the computational complexity of determining N-point DFT by direct method and using radix-2 FFT algorithm.

2014-15

SATELLITE COMMUNICATION

ECE 712

Full Marks : 70 *Time* : 3 hours

The questions are of equal value.

Answer any *five* questions.

1. What are look angles ? Discuss different orbital effects in communications. What is an eclipse ?

2. Discuss in details the Attitude and orbit control system (AOCS) in a spacecraft. What is the power system needed in a spaceccraft ?

3. Write in details the objectives of downlink design of any satellite communication system.

   A satellite at a distance of 40,000 km from a point on the earth's surface radiates a power of 2w from an antenna with a gain of 17 dB in the direction of the observer. Find the flux density at the receiving point and the power received by an antenna with an effective area of 10 m².

4. What do you mean by system noise temperature ? Derive the expression for the system noise temperature for a satellite communication receiver.

   For a 4 GHz receiver with the following gains and noise temperatures :

   $T_m = 50$ k

$T_{RF} = 50$ k

$T_m = 500$ k

$T_{IF} = 1000$ k

$G_{RF} = 23$ dB

$G_m = 0$ dB

$G_{IF} = 30$ dB

Calculate the system noise temperature.

An amplifier has a quoted noise figure of 2.5 dB. What is its equivalent noise temperature ?

5. What is QPSK ? Prove that QPSK will have a higher bit error rate (BER) when the modulation schemes are compared for equal bit rates, bandwidths and (C/N) values.

6. What is multiple access ? Why the multiple access is fundamental to satellite communication ?

   Briefly describe different multiple access techniques in satellite communication system.

   Derive the expression for the overall carrier-to-noise ratio on an FDM/ FM/ FDMA link.

7. Derive the expression for (S/N) ratio for satellite TV links.

   Define briefly bit and symbol error rates.

   What is SPADE ?

8. Write short notes on any *two* of the following :

   (*a*) Traffic intensity

   (*b*) Orbital elements

   (*c*) Space craft antennas

   (*d*) Required (S/N) in a voice channel

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2014-15

MICROWAVE CIRCUITS

ECE 714

Full Marks : 70 *Time* : 3 hours

The figures in the margin indicate full marks.

Write down serially the question number attempted in the space provided on the top sheet of the answerscript

Answer any *five* questions.

1. Derive the expressions for the electric and magnetic field intensities in a circular waveguide for H-wave. 14

2. An air-filled circular cylindrical waveguide is to be operated at a frequency of 5 GHz and is to have dimension such that $\lambda_0/\lambda_c = 0.9$ for the dominant mode. Given that $p'_{11} = 1.841$.

   Find the diameter of the guide, the propagation constant, attenuation constant, phase-shift constant, free-space wavelength, cut-off frequency, cut-off wavelength, guide wavelength, phase velocity, group velocity, f/f_c ratio, $\overline{\lambda} / \lambda_0$ ratio, λ_c / λ_0 ratio, and characteristic wave impedance. Derive the necessary formulae you use. 14

3. Deduce the expressions for the electric and magnetic field intensities in a rectangular waveguide for the dominant mode. 14

4. An air-filled rectangular waveguide of inside dimensions 2 cm × 1 cm is recommended for use in the dominant mode for X band. Determine the propagation constant, attenuation constant, phase-shift constant, free-space wavelength, cut-off frequency, cut-off wavelength, guide wavelength, phase velocity, group velocity, a/b ratio, f/f_c ratio, $\overline{\lambda} / \lambda_0$ ratio, λ_c / λ_0 ratio, and characteristic wave impedance of a wave at a signal frequency of 10 GHz. Derive the formulae you use. 14

5. (*i*) Derive the expression for the Q_w of a rectangular cavity resonator excited in TE_{101} mode. What will be the value of Q_w of cubical resonator in the above mode ? 7

   (*ii*) A rectangular cavity has cross-section 0.76 cm × 0.38 cm. If it oscillates in the TE_{102} mode at 50 GHz, calculate the length 'd' of the cavity and resonant wavelength considering air as a dielectric. Derive the formulae you use. 4 + 3

6. (*i*) Derive the expressions for resonant frequency and resonant wavelength of a circular cylindrical cavity resonator both in TE and TM mode. A circular cylindrical cavity resonator has dimensions a = 3.4 cm and d = 12 cm. Calculate the resonant frequency and resonant wavelength for the TE_{111} mode. The 3-dB bandwidth is measured to be 2.4 MHz. Find the Q of the cavity considering air as dielectric. Given that $p'_{11} / 1.84$ 2 + 2 + 2 + 1

   (*ii*) What do you mean by 'Quality factor', 'dominant resonant mode' and 'degenerate modes' as are used in connection with the cavity resonators ? What is wavemeter ? A circular cylindrical cavity resonator has dimensions a = 4 cm and d = 12 cm. Calculate the resonant frequency and resonant wavelength for the TM_{011} mode. The 3-dB bandwidth is measured to be 3 MHz. Find the Q of the cavity considering air as dielectric. Given that $p_{01} = 2.405$. 1 + 1 + 1 + 1 + 2 + 1

7. (*i*) Derive the expressions for efficiency and voltage gain in a two-cavity klystron amplifier. 7

   (*ii*) A two-cavity klystron amplifier tube has the following parameters : V_0 = 900 volt, f = 8 GHz, d = 1 mm, M = 0.9 and V_1 = 20 volt. Determine the following :

   (*a*) The electron velocities.

   (*b*) The distance of the buncher cavity from the location of the dense electrons. 4 + 3

8. A reflex klystron has its anode at 300 volt positive w.r.t the cathode and it is found that the output maxima occurs at reflector voltages of – 80 volt and – 160 volt measured w.r.t the cathode. Calculate the next values of the reflector voltages at which the power output will be a maxima. Derive the formulae you use. 14

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