I.E.S-(Conv.)-2007

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

PAPER - I

Time Allowed: 3 hours *Maximum Marks : 200*

Candidates should attempt any FIVE questions.

The number of marks carried by each question is indicated at the end of the question.

Assume suitable data, if found necessary, and indicate the same clearly.

Values of the following constants may be used wherever necessary

Electronic charge = -1.6×10^{-19} Coulomb.

Free space permeability = $4\pi \times 10^{-7}$ Henry/m.

Free space permittivity = $(1/36\pi) \times 10^{-9}$ Farad/m;

Velocity of light in free space = 3×10^{8} m/sec.

Boltzmann constant = 1.38×10^{-23} Joule/K.

Planck's constant = 6.625×10^{-34} Joule.sec.

1. (a) Show that the dielectric loss in a medium is proportional to the imaginary part of the complex dielectric constant.

15

(b) Define carrier mobility. Draw a graph showing the variation of carrier mobility in a semiconductor with increasing temperature.

A 100-ohm resistor is to be made at room temperature in a rectangular silicon bar of 1 cm in length and 1 mm^2 in cross-sectional area by doping it appropriately with phosphorous atoms. If the electron mobility in silicon at room temperature be 1350 cm^2/V. sec, calculate the dopant density needed to achieve this. Neglect the insignificant contribution by the intrinsic carriers.

15

(c) A material has $\sigma = 10^{-2}$ siemens/meter and $\varepsilon = 3\varepsilon_0$. At what frequency (Hz) will the displacement current equal the conduction current?

10

2. (a) Draw a neat sketch of the terminal drain-current versus drain-voltage characteristics of an n-channel enhancement mode MOSFET and explain the characteristics.

15

(b) Indicate whether the β-value of a BJT increases or decreases with increase in the values of the following parameters:

(i) base width.

(ii) minority carrier lifetime in the base region.

(iii) temperature.

(iv) collector current.

(v) collector voltage.

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(c) In the circuit shown in Fig. 2 (c), what would be the minimum value of β such that the transistor is in saturation ? Assume $V_{CE\ sat}$ = 0.2V.

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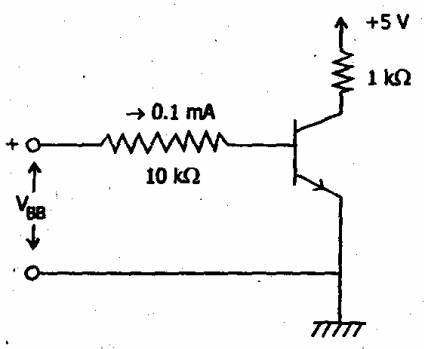

Fig. 2(c)

3. (a) Determine the response of the system

$$y(n)=\frac{5}{6}y(n-1)-\frac{1}{6}y(n-2)+x(n)$$

to the input signal

$$x(n)=\delta(n)-\frac{1}{3}\delta(n-1).$$

15

(b) Explain the condition of BIBO stability of a system in the Z-domain.

A linear time-invariant. system is characterized by the system function:

$$H(z)=\frac{3-4z^{-1}}{1-3.5z^{-1}+1.5z^{-2}}$$

Specify the region of convergence (ROC) and determine h(n), when

(i) the system is stable

(ii) the system is causal.

15

(c) The impulse response of a relaxed linear time-invariant system is $h(n) = a^n u(n)$ with $|a| < 1$. Determine the value of the step response as $n \to \infty$.

10

4. (a) A signal generator with terminal voltage v 10 sin ($2\pi . 10^6$ t) and internal resistance of 1 ohm is supplying power to a variable load. Calculate:

(i) the maximum rms power that the generator can generate,

(ii) the maximum rms power that the generator can deliver to an external load,

(iii) the rms power that it generates when delivering maximum power to the load.

15

(b) Find the current through the 5-ohm resistor in the circuit shown in Fig. 4(b).

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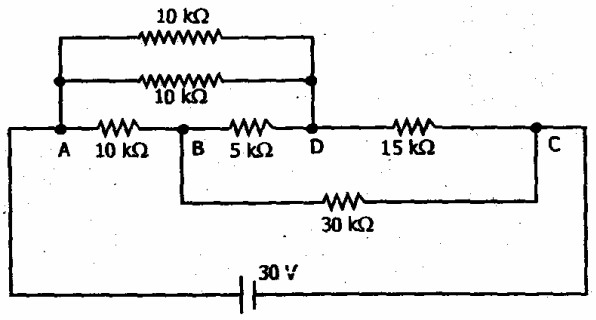

Fig. 4(b)

(c) State and explain the "Superposition Theorem".

10

5. (a) The switch, S, jn the circuit shown in Fig. 5(a) is open for a long time. At t = 0, S, is closed connecting the voltage source to the circuit. For t> 0, obtain the voltage v_c across the capacitor.

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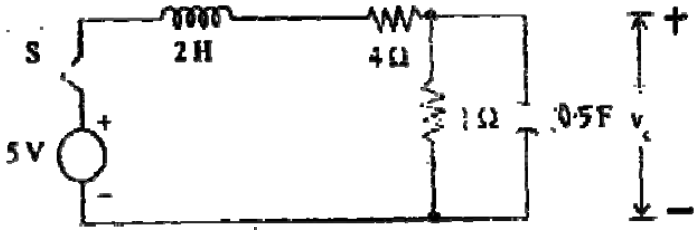

(b) Find the transfer function $H(s) = \dfrac{V_2(s)}{V_1(s)}$ for the network shown in Fig. 5(b). What is the order of the system?

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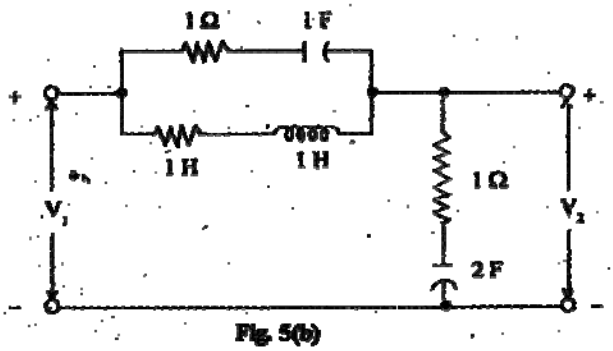

Fig. 5(b)

(c) Obtain resonant frequency of the circuit shown in Fig. 5(c). Given L = 0.1 H, R_L = 10Ω, C = 10 μF and R_c = 2 kΩ.

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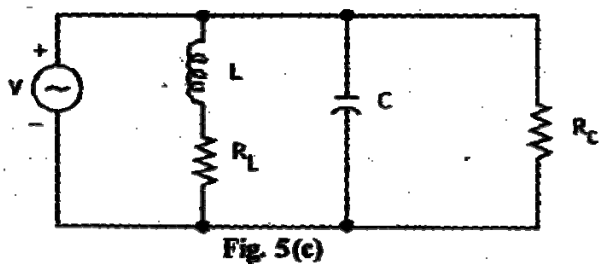

Fig. 5(c)

6. (a) Write down Maxwell's equations for time-varying fields in both the differential and the integral forms. Also write down the word statements of these equations from the mathematical statements in the integral form.

8+7

(b) The electric field of a plain wave is given by:

$$\vec{E} = 10\cos\left(10^9 t + 30z\right)\hat{y}\ v/m$$

where $\hat{y}$ is the unit vector along the y-direction.

Determine

(i) the magnetic field, H

(ii) the phase velocity, v_p

(iii) dielectric constant, ε_r of the medium when $\mu = \mu_0$.

15

(c) A transmission line has a characteristic impedance of 50Ω and is terminated by a load impedance of (75 – j50)Ω. Calculate:

(i) the reflection coefficient

(ii) the standing-wave ratio.

10

7. (a) Explain, using a heat block schematic, why delay lines are used in the vertical deflection circuit of a cathode ray oscilloscope (CRO). Name at least two types of delay lines used in a CRO.

15

(b) What is the difference between accuracy and precision of a measuring instrument ? Define sensitivity of a voltmeter.

When a voltmeter is connected across either of the two 100 kΩ resistors in Fig. 7(b), it shows a reading of 90 V when it should have shown 100 V. Explain clearly why this is happening.

Also calculate the internal resistance of the voltmeter being used.

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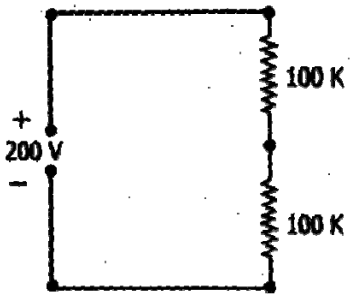

Fig. 7(b)

(c) The output of an LVDT is connected to a 5 V voltmeter through an amplifier having an amplification factor of 250. An output of 2 mV appears across the terminals of the LVDT when the core, moves through a distance of 0.5 mm Calculate the sensitivity of the LVDT and that of the whole set up. The millivoltmeter scale has 100 divisions. The scale can be read to ½ of a division. Calculate the resolution of the instrument in mm.

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ELECTRONICS AND TELECOMMUNICATION ENGINEERING

PAPER - II

Time Allowed: 3 hours *Maximum Marks : 200*

Candidates should attempt Question No. 1 which is compulsory and FOUR more questions taking TWO each from Section 'A' and Section 'B'.

Assume suitable data, if required.

Some useful constants are given below :

Electron charge	: $e = 1.6 \times 10^{-19}$ Coulomb
Electron mass	: $M = 9.1 \times 10^{-31}$ kg
Planck's constant	: $h = 6.625 \times 10^{-34}$ J-s
Velocity of light	: $c = 3 \times 10^{8}$ m/s
Universal constant of gravitation	: $G = 6.668 \times 10^{-11}$ $m^3/kg\text{-}s^2$
Mass of earth	: $M = 5.997 \times 10^{24}$ kg
Radius of earth	: R = 6,378 km
Permeability of vaccum	: $\mu_0 = 4\pi \times 10^{-7}$ H/m
Permittivity of vaccum	: $\varepsilon_0 = 10^{-9}/36\pi$ F/m.

1. (a) Arrange the following A/D converters in order of increasing speed of operation :

(i) Successive approximation

(ii) Dual-slope

(iii) Flash

(iv) Single-slope

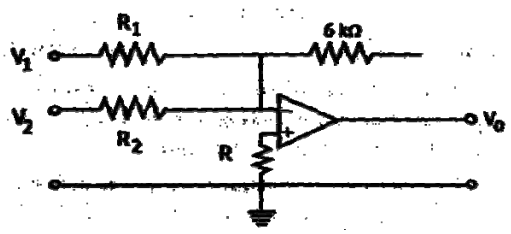
An 8-bit successive approximation type A/D converter uses a clock frequency of 1 MHz. Calculate the conversion time of the converter.

Why is a dual-slope A/D converter preferred in a digital voltmeter?

8

(b) The circuit shown simulates the relation $V_0 = -2V_1 - 3V_2$. Determine the value of R

8



(c) A partially filled truth table of a sequence generator (3 D flip-flops in cascade) is given below. Complete the table and find the sequence generated:

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	MSB		*LSB*
State	Q_2	Q_1	Q_0
1	1	0	0
2			
3			
4	1		
5	0	1	1
6			
7			
1	1	0	0

(d) A certain D/A converter has the lowest and highest values of resistances 1 kΩ and 8 kΩ, respectively. If the bit length of the converter is increased by 2, what would be the number of additional resistors and their values? Draw a neat circuit of the converter. What is the drawback of such a converter?

8

(e) A unity feedback system has a forward Loop transfer function:

$$G(s) = \frac{k}{(s+1)^3(s+4)}$$

Determine:

(i) the range of k for closed-Loop system stability,

(ii) the frequency of oscillations when the system is marginally stable.

8

(f) The bit rate in the 1st level CCIT multiplexer output is 2.048 Mbps. It contains 30 voice samples of 8-bit each sampled at Nyquist rate of 8 kHz. Calculate the control bits per frame. If this signal is transmitted using 16-QAM, calculate the baud rate.

8

(g) For a standard voice band communication channel, the signal-to-noise ratio is 30 dB and transmission bandwidth is 3 kHz. What will be the Shannon limit for information in bits/s ? (Given $3.32 \log_{10} a = \log_2 a$)

What is the equivalent noise temperature if the cascaded system is held at an environmental temperature of 290K?

8

(h) Draw the velocity field characteristics of an n-type GaAs Gunn diode and show the region of negative differential mobility. An n-type GaAs Gunn diode has the following parameters:

Thershold field E_{th} = 3 kV/cm

Applied field E = 3.4 kV/cm

Device length L = 12 μm

Doping concentration $n_0 = 1 \times 10^4$ cm^{-3}

Operating frequency f = 12 GHz.

Determine:

(i) the electron drift velocity.

(ii) negative electron velocity.

8

(i) A slotted line is terminated by different types of microwave load.

Draw the voltage standing wave setup within rectangular waveguide when it is terminated by the following types of load:

(i) shorted load (ii) Matched load

Hence determine the value of VSWR of shorted load and matched load.

In a shorted line measurement at 10 GHz, VSWR is found to be 15 and the characteristic impedance of the guide is 50 Ω.

What will be the magnitude of reflection coefficient?

8

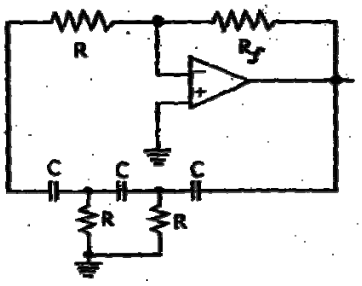
(i) (i) If x = 111.101 and y = 101.110 (both in binary), calculate x + y and $\left.\begin{matrix} x-y \\ y-x \end{matrix}\right\}$ by 2's complement method.

(ii) Calculate the exact number of comparisons (i.e., execution of conditional statement) required for sorting an array of n elements by bubble sort.

8

SECTION A

2. (a) "Minimum 3 identical RC high-pass sections connected in cascade are required in a phase-shift oscillator." Justify. One such phase-shift oscillator is shown below. Why is R of one section connected to virtual ground instead of actual ground?



Determine the value of R_f.

What should be the next higher number of high-pass sections connected in cascade? Draw the corresponding circuit of the oscillator. Component values are not required.

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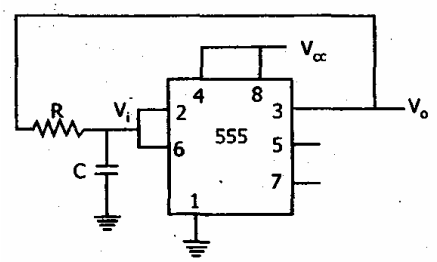
(b) Give pin numbers for the 'Trigger' and 'Threshold' of the timer 555.

In the circuit shown, assume V_0 = 12 V and 0 as possible outputs for V_0.



Draw the waveforms for the voltages V_0 and V_i.

Determine the frequency of V_0 waveform and the duty- cycle.

15

3. (a) A synchronous counter uses JK flip-flops and gives outputs (Q_2 Q_1 Q_0) in the sequence 000, 010, 101, 110 and resets to 000 from all unused states. Determine the J_1 and K_1 inputs to the Q_1 flip-flop.

10

(b) Simplify the logic function:

$$f(A,B,C,D) = \bar{A} + A\bar{C} + \bar{A}\bar{B}C + AB\bar{C}D + ABCD$$

Draw the corresponding logic circuit.

10

(c) Draw the circuit of a 2-input X-OR gate using CMOS transistors and explain its operation.

10

4. (a) A system is represented by the signal flow graph as shown in the figure. The variable T is the torque and E is the error. Determine –

(i) the overall transfer function, if k_1= 5, k_2 = 1 and k_3 = 5.

(ii) the sensitivity of the system to changes in k_2 for ω=0.

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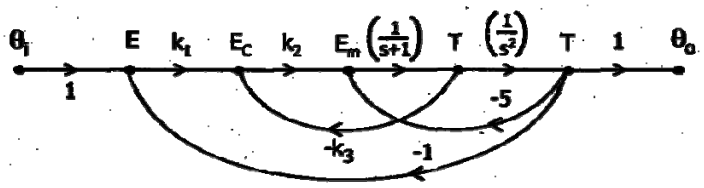


(b) A closed-loop system is represented by

$$\frac{d^2c}{dt^2} + 4.8\frac{dc}{dt} = 144e$$

where, e = r – 0.5c is the actuating signal. Find the value of the damping ratio, damped and undamped frequency of oscillations. Draw the block diagram of the system.

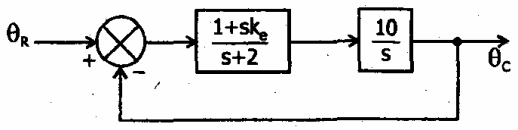
10

(c) A system employing a proportional and an error-rate control is shown in the figure. Determine –

(i) the error-rate factor k_e, so that the damping ratio is 0.5;

(ii) the settling time, maximum overshoot and steady-state error for unit ramp input.

10

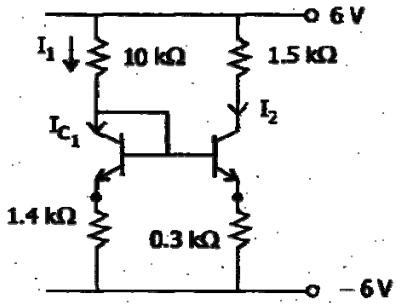


5. (a) In the circuit shown, the two transistors are matched. Find an expression for I_1 in terms of IC_1 and β.

Assume V_{BE} = 0.6 V and β to be very large, calculate I_1 and I_2.

Calculate I_{C_1}, when β = 20.

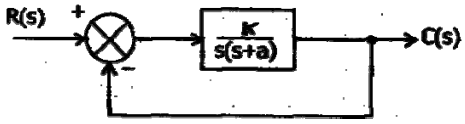
10



(b) Design a simple logic Circuit such that the output is 1 when the binary number ABCD is greater than 0110.

10

(c) (i) For the system shown in the figure, obtain the values of k and a, to satisfy, M_r = 1.04 and ω_r = 11.55 rad/sec.



(ii) A unity feedback system has an open-loop transfer function

$$G(s) = \frac{10(s+1)}{s(s+2)(s+5)}$$

Determine the steady-state error for r(t) = 3 + 10t.

6+4

SECTION B

6. (a) An SI fiber has NA = 0.173 and supports 400 modes at a wavelength of 1.3 μu. Calculate its core area. To what value its core area should be reduced so that it is single-mode fiber at λ ≥ 1.3 μm?

10

(b) For a 100 km FO link, fibers with 10 km unit lengths and having attenuation loss of 0.4 dB/km are used. Connector which is used between two unit lengths is having 1 dB loss. If the receiver sensitivity is 10 nW/Mbps, calculate the maximum bit rate so that only one repeater is used in the link. Assume one connector loss at fiber receiver coupling. Power launched onto the fiber is 0 dBm.

10

(c) Consider a rectangular RF pulse of duration T given as

$$\phi(t) = \cos 2\pi f_c t \quad 0 \le t \le T$$
$$= 0 \quad \text{elsewhere}$$

Draw the pulse for $f_c = 5/T$. If the pulse energy is 10^{-3} joules, find the duration of the pulse. Show that the impulse response of a filter matched to this $\phi(t)$ is same as $\phi(t)$.

10

7. (a) Explain the following parameters used to characterize a directional coupler:

(i) Coupling coefficient

(ii) Directivity

(iii) Isolation

What will be the value of directivity and isolation for an ideal directional coupler?

An X-band directional coupler has a coupling coefficient of 10 dB. What will be the output power in the main branch if the input power is 20 mW?

15

(b) Draw the block diagram for microwave setup for measuring the frequency of an X-band microwave signal employing slotted line technique. Write the procedural steps including mention of any formula to be followed for measurement. What is the alternative technique for microwave frequency measurement?

15

8. (a) What are the important elements involved in a micro processor based system for the measurement and monitoring of a temperature of a liquid contained in a furnace ? Draw the block diagram for this setup (which should include blocks like transducer, actuator, etc.) and explain the salient features of each of its blocks.

20

(b) For an 8085 microprocessor –

(i) write an instruction to left shift 16-bit data stored in 16-bit register pair.

(ii) what should generally be the first instruction for an assembly language program containing CALL instruction(s) ? What is its significance ?

(iii) an assembly language program is given below:

```
MVI A, B5H
MVI B, 0EH
XRI 69 H
ADD B
ANI 9BH
CPI 9FH
STA 3010H
HLT
```

What is the status of ‘carry’ and ‘zero’ flags after the execution of the program?

10

9. (a) A source emits seven symbols x_1, x_2,……, x_7 with probabilities 0.35, 0.3, 0.2, 0.1, 0.04, 0.005, 0.005 respectively. Give Huffman ceding for these symbols and calculate average bits of information and average binary digits of information per symbol.

10

(b) Examine whether the following modes propagate inside an air-filled rectangular waveguide of dimension 7.21 cm × 3.40 cm operating at 5 GHz:

TE_{01},TM_{11} and TE_{30}

Find out the velocity of TE_{10} mode of propagation. Waveguide can be treated as a high-pass filter at microwave frequency. Justify.

10

(c) What should be the minimum number of instructions by which one can achieve all possible operations in a high-level programming language like PASCAL/C ? Mention them with one example each.

10

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