Sikkim Public Service Commission

Main Written Examination for the Post of Sub Inspector

PAPER - II ELECTRONICS COMMUNICATION & ENGINEERING

Time allowed: 3.00 Hrs | Maximum Marks: 250

INSTRUCTIONS TO CANDIDATES

***Read the instructions carefully before answering the questions*: -**

1. **IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS BOOKLET DOES NOT HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.**
2. **Use only Black Ball Point Pen to fill the OMR Sheet.**
3. Do not write anything else on the OMR Answer Sheet except the required information.
4. **This Test Booklet contains 50 questions in MCQ Mode in Part I to be marked in OMR Sheet. Part II and Part III are Subjective Questions which have to be written on separate answer sheet provided to you.**
5. Before you proceed to mark in the Answer Sheet (OMR), you have to fill in some particulars in the Answer Sheet (OMR) as per given instructions.
6. After you have completed filling in all your responses on the Answer Sheet (OMR) and the examination has concluded, you should hand over the Answer Sheet (OMR) and separate answer sheet to the Invigilator only. You are permitted to take with you the Test Booklet.
7. **Marking Scheme**

   THERE WIL BE NEGATIVE MARKING FOR WRONG ANSWERS MARKED BY A CANDIDATE IN THE OBECTVE TYPE QUESTIONS

   i. There are four alternatives for the answer to every question. For each question for which a wrong answer has been given by the candidate, one-third of the marks assigned to the question will be deducted as penalty.
   ii. If a candidate gives more than one answer, it will be treated as a wrong answer even if one of the given answers happens to be correct and there will be same penalty as above to the question.
   iii. If a question is left blank. i.e., no answer is given by the candidate; there will be no penalty for that question.

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

PART - I

Choose the correct answer for the following questions: **(3x50=150)**

1. A low earth orbit satellite can provide large signal strength at an earth station because

A. Path loss is low
B. These orbits are immune to noise.
C. Large solar power can be generated at these orbits
D. Lower microwave frequencies in S-band can be used.

2. In microwave relay communication, the repeater is usually an amplifier for the amplification of

A. Carrier Signal
B. Baseband signal
C. Amplitude modulated IF signal
D. Frequency modulated IF signal

3. For an earth station, transmitter with an antenna output power of 40 dBW (10,000W), a back-off loss 3 dB, a total branching and feeder loss of 3dB and transmit antenna gain of 4 dB, the effective isotropic radiated power (EIRP) will be

A. 38 dBW
B. 40 dBW
C. 36 dBW
D. 47 dBW

4. Which type of network is the Internet?

A. Circuit-switched network
B. Message-switched network
C. Packet-switched network
D. Cell-switched network

5. The normalized frequency of a step index fibre is 28 at 1300 nm wavelength. What is the total number (approximately) of guided modes that can be supported by the fibre?

A. 50
B. 200
C. 400
D. 800

6. Polarization mode dispersion (PMD) is mainly observed in

A. Multiple step-index fibre
B. Single mode fibre
C. Multimode graded-index fibre
D. Plastic Fibre

7. In an optical communication system, having an operating wavelength λ in metres, only X% of its source frequency can be used as its channel bandwidth. The system is to be used for transmitting TV signal requiring a bandwidth of f Hz. The number of channels transmitted by this system simultaneously is (c=speed of light)

A. $\frac{100Xc}{\lambda f}$

B. $\frac{100\lambda f}{Xc}$

C. $\frac{Xc}{\lambda f}$

D. $\frac{Xc}{100\lambda f}$

8. In graded index multimode optical fiber, the refractive index of the core is

A. uniform across its radial distance, except for the cladding

B. maximum at the fiber axis and decreases stepwise towards the cladding

C. maximum at the fiber axis and decreases gradually towards the cladding.

D. maximum at the fiber axis and increases stepwise towards the cladding.

9. A carrier waveform $10\cos(\omega_c t)$ and modulating signal $3\cos(\omega_m t)$ have $f_c = 100kHz$ and $f_m = 4kHz$ Given that sensitivity of FM is 4kHz/V and FM spectra beyond J_6 is negligible, what are the channel bandwidth requirements for AM and FM respectively?

A. 12 kHz and 48 kHz

B. 8 kHz and 48 kHz

C. 12 kHz and 24 kHz

D. 8 kHz and 24 kHz

10. The threshold effect in demodulators is

A. the rapid fall of output SNR when the input SNR falls below a particular value.

B. exhibited by all the demodulators when the input SNR is low.

C. exhibited by all AM suppressed carrier coherent demodulators.

D. exhibited by correlation receivers

11. Let $x(n)$ be a real-valued sequence that is a sample sequence of a wide-sense stationary discrete-time random process. The power density of this signal is

A. real, odd and non-negative

B. real, even and non-negative

C. purely imaginary, even and negative

D. purely imaginary, odd and negative

12. A random variable X is defined by the double exponential distribution $\rho_x(x) = ae^{-b|x|}; -\infty < x < \infty$ where a and b are positive constants. What is the relation between a and b so that $\rho_x(x)$ is a probability density function?

A. a=b/2

B. b=a/2

C. a=b

D. a=1/b

13. 1 Mbps BPSK receiver detects waveform $s_1(t) = A\cos\omega_0 t$ or $s_2(t) = -A\cos\omega_0 t$ with a matched filter. If A=1mV, then the average bit error probability assuming single-sided noise power expected density $N_0 = 10^{-11} W/Hz$ is nearly

A. $Q(0.63)$

B. $Q(0.16)$

C. $Q\left(\sqrt{0.1}\right)$

D. $Q\left(\sqrt{0.3}\right)$

14. Discrete source S_1 has 4 equiprobable symbols while discrete source S_2 has 16 equiprobable symbols. When the entropy of these two sources is compared, entropy of

A. S_1 is greater than S_2

B. S_1 is less than S_2

C. S_1 is equal to S_2

D. Depends on rate of symbol/second

15. The average information associated with an extremely unlikely message is zero. What is the average information associated with an extremely likely message?

A. Zero

B. Infinity

C. Depends on speed of transmission of the message

D. Depends on total number of messages

16. A radio channel has bandwidth of 10kHz and an S/N ratio of 15dB. The maximum data rate that can be transmitted is

A. 16.1 kb/sec

B. 24.2 kb/sec

C. 32.3 kb/sec

D. 50.3 kb/sec

17. An antenna consists of 4 identical Hertzian dipoles uniformly located along the z-axis and polarized in z-direction. The spacing between the dipoles is $\lambda/4$. The group pattern function is

A. $4\cos\left(\frac{\pi}{4}\cos\theta\right)\cos\left(\frac{\pi}{2}\cos\theta\right)$

B. $4\cos\left(\frac{\pi}{4}\cos\theta\right)\cos\left(\frac{\pi}{8}\cos\theta\right)$

C. $4\cos\left(\frac{\pi}{4}\cos\theta\right)\sin\left(\frac{\pi}{2}\cos\theta\right)$

D. $4\cos\left(\frac{\pi}{4}\cos\theta\right)\sin\left(\frac{\pi}{8}\cos\theta\right)$

18. An antenna array consists of omni-directional elements carrying equal in-phase currents. The elements are equally spaced along x-axis with the spacing between adjacent elements being equal to one wavelength. The directivity pattern will have a maximum

A. only in x-direction

B. only in y-direction

C. both x- and y-direction.

D. in the direction making an angle of $45°$ with x-axis.

19. In a radar system, if the peak transmitted power is increased by a factor of 16 and the antenna diameter is increased by a factor of 2, then the maximum range will increase by a factor of

A. 16

B. 8

C. 4

D. $\sqrt{8}$

20. The waveguide (a=1.5 cm, b=1cm) is loaded with dielectric $(\varepsilon_r = 4)$. The 8GHz signal will

A. pass through the waveguide

B. not pass through the waveguide

C. be absorbed in the guide

D. none of the above

21. For a WR 90 waveguide, the cut-off frequency for TE_{20} mode is 16 GHz. Then the cut-off frequency for TE_{11} mode will be

A. $4\sqrt{3}$ GHz

B. $6\sqrt{3}$ GHz

C. $8\sqrt{5}$ GHz

D. $16\sqrt{5}$ GHz

22. Consider the following statements regarding Smith Charts:

i. A normalized Smith Chart applies to a line of any characteristic resistance and serves as well as for normalized admittance.
ii. A polar coordinate Smith Chart contains circles of constant $|Z|$ and circles of constant $\angle Z$
iii. In Smith chart, the distance towards the load is always measured in clockwise direction

Which of the following statements given above are correct?

A. 1, 2 and 3

B. 2 and 3

C. 1 and 3

D. 1 and 2

23. **A uniform plane electromagnetic wave is normally incident upon a thick magnetic material such that its complex permittivity is equal to its complex permeability i.e. $\mu^* = \varepsilon^*$. Which one of the following is the correct statement?**

A. There will not be any reflection from the material

B. A part of the wave will be reflected such that reflection coefficient would be 0.5.

C. Reflection coefficient would be close to 1.

D. Transmission coefficient would be 0.9.

24. **The function $F = e^{-\alpha z}\sin\frac{\omega}{v}(x - vt)$ satisfies the wave equation $\nabla^2 F = \frac{F}{c^2}$ provided**

A. $v = c\left(1 + \frac{\alpha^2 c^2}{\omega^2}\right)^{-1/2}$

B. $v = c\left(1 + \omega^2\alpha^2 c\right)^{-1/2}$

C. $v = c\omega\left(\alpha^2 c^2 - 1\right)^{-1/2}$

D. $v = \frac{1}{c}\left(1 + \frac{\omega^2 c^2}{\alpha^2}\right)^{-1/2}$

25. **A sphere of homogeneous linear dielectric material of dielectric constant ≥ 1 is placed in a uniform electric field E_0, then the electric field E that exists inside the sphere is**

A. Uniform and $E \leq E_0$

B. Uniform and $E \geq E_0$

C. Varies but $E < E_0$ always

D. Varies but $E > E_0$ always

26. **A transmission line, has a characteristic impedance (Z_0) of 600Ω. Its length is 500m. If the line is cut into half, what will be the Z_0 for each half?**

A. $\frac{Z_0}{4}$

B. $\frac{Z_0}{2}$

C. Z_0

D. $2Z_0$

27. The output data lines of microprocessors and memories are usually trisated, because

A. More than one device can transmit information over the data bus by enabling only one device at a time.

B. More than one device can transmit information over the data bus at the same time.

C. The data lines can be multiplexed for both input and output.

D. It increases the speed of data transfers over the data bus.

28. A small code of 8085 as given below, is executed

```
MVI A, 7F H
ORA A
CPI A2 H
```

The contents of the accumulator and flags after the execution are

A. A=DD, S=1, Z=0, CY=0

B. A=7F, S=1, Z=0, CY=1

C. A=DD, S=0, Z=1, CY=0

D. A=7F, S=0, Z=1, CY=1

29. Consider the following loop:

```
MOV CX, 8000h
L1: DEC CX
JNZ L1
```

The processor is running at 14.7456/3 MHz and DEC CX requires 2 clock cycles and JNZ requires 16 clock cycles. The total time taken is nearly

A. 0.01 secs

B. 0.12 secs

C. 3.66 secs

D. 4.19 secs

30. What are the number of machine cycles n, and the type of machine cycles carried out for PUSH B?

A. n=2, fetch and memory write

B. n=3, fetch and 2 memory write

C. n=3, fetch memory write and read

D. n=3, fetch, and 2 memory read

31. In mode 0, Interrupt on terminal count of 8253, if the gate pin is made low while counter is decrementing, which one of the operations will be followed?

A. Counter stops and cleared to 0 and starts decrementing when gate pin is made high.

B. Counter stops and thereafter it increments till gate pin= '1' high.

C. Counter stops, the current contents are held, and the decrement operation resumes only after gate pin is made high.

D. Counter stops, the current contents are held for one clock cycle and the decrement operation resumes.

32. For 8086 microprocessors, the jump distance in bytes for short jump range is

A. Forward 255 and Backward 256

B. Forward 127 and Backward 128

C. Forward 31 and Backward 32

D. Forward 15 and Backward 16

33. The type of device used to interface a parallel data format with external equipment's serial format is

A. Key Matrix

B. UART

C. Memory chip

D. Serial-in, parallel-out

34. A voltage of 24 V DC is applied through switch S to an R-L series circuit. Switch S was initially open. At time t=0, switch is closed. The rate of change of current through the resistor is 8A/sec, while current through the inductor is 8A. If the value of inductor is 1H, then for this condition the value of the resistor will be

A. 1 Ω

B.2 Ω

C. 3 Ω

D.4 Ω

35. A 2-port network has parameters ABCD. If all the impedances in the network are doubled, then

A. A and D remain unchanged, B is doubled, and C is halved.

B. A, B, C and D are all doubled.

C. A and D are doubled; C and B remain unchanged.

D. A and D remain unchanged, C is doubled, and B is halved.

36. For a given connected network and for a fixed tree, the fundamental loop matrix is given by $B=\begin{bmatrix}1&0&0&1&0&0\\0&1&0&0&0&-1\\0&0&1&1&-1&-1\end{bmatrix}$

The fundamental cut-set matrix Q corresponding to the same tree is given by

(A) $Q=\begin{bmatrix}-1&0&-1&1&0&0\\0&0&1&0&1&0\\0&1&1&0&0&1\end{bmatrix}$

(B) $Q=\begin{bmatrix}-1&0&1&1&0&0\\0&0&-1&0&1&0\\0&1&1&0&0&1\end{bmatrix}$

(C) $Q=\begin{bmatrix}1&0&1&1&0&0\\0&0&-1&0&1&0\\0&1&1&0&0&1\end{bmatrix}$

(D) $Q=\begin{bmatrix}0&0&0&1&0&0\\0&1&0&0&0&-1\\1&0&1&1&-1&-1\end{bmatrix}$

37. A reactive network has poles at $\omega=0,4000$ rad/sec and infinity and zeros at $\omega=2000$ and 6000 rad/sec. The impedance of the network is $-j700\Omega$ at 1000 rad/sec. What is the correct expression for driving point impedance?

(A) $-j(0.1\omega)\dfrac{(\omega^2-4*10^6)(\omega^2-36*10^6)}{\omega^2(\omega^2-16*10^6)}\Omega$

(B) $j(0.1\omega)\dfrac{\omega^2(\omega^2-16*10^6)}{(\omega^2-4*10^6)(\omega^2-36*10^6)}\Omega$

(C) $j(0.1\omega)\dfrac{(\omega^2-4*10^6)(\omega^2-36*10^6)}{\omega^2(\omega^2-16*10^6)}\Omega$

(D) $-j(0.1\omega)\dfrac{\omega^2(\omega^2-16*10^6)}{(\omega^2-4*10^6)(\omega^2-36*10^6)}\Omega$

38. The built-in potential (diffusion potential) in a p-n junction

i. is equal to the difference in Fermi-level of the two sides, expressed in volts.
ii. increases with the increase in the doping levels of the two sides.
iii. increases with the increase in temperature.
iv. is equal to the average of Fermi levels of the two sides

Which of the above statements are correct?

A. i and ii only
B. i and iii only
C. i, ii and iii
D. ii, iii and iv.

39. If the α value of a transistor changes 0.5% from its nominal value of 0.9, the % change in β will be

A. 0%
B. 2.5%
C. 5%
D. 7.5%

40. In an n-channel enhancement MOSFET at a fixed drain voltage

A. drain current is maximum at zero gate voltage and it decreases with applied negative gate voltage.

B. drain current has a finite value at zero gate voltage and it increases or decreases with the applied voltage of proper polarity.

C. drain current is zero at zero gate voltage and it increases with the positive applied gate voltage.

D. drain current is zero for negative bias voltage to gate and it increases as the negative bias is decreased in magnitude.

41. In tunnel diode, Fermi level lies

A. in the energy band gap but closer to conduction band of n-type semiconductors.

B. in the energy band gap but closer to valence band of p-type semiconductors

C. in the energy band gap but above valence band of p-type and below conduction band of n-type semiconductors.

D. inside valence band of p-type and inside conduction band of n-type semiconductors.

42. In the case of small BJT model **with common emitter**, the collector current i_c is 1.3mA, when the collector-emitter **voltage is** V_{ce} **of 2.6 V.** The output conductance of the circuit is.

A. 2.0 mΩ

B. 2.0 m℧

C. 0.5 mΩ

D. 0.5 m℧

43. Which one of the following **equations is correct** for a MOSFET common-source amplifier? (g_m is mutual conductance, **and** R_D **is load** resistance at the drain)

A. $A_v = g_m / R_d$

B. $A_v = g_m R_D$

C. $A_v = g_m / (1 + R_D)$

D. $A_v = R_D / g_m$

44. A tuned amplifier has a **maximum output at 4MHz** with a quality factor of 50. The bandwidth and half power **frequencies are, respectively**

A.80 kHz and 4.04 MHz; 3.96 MHz

B.80 kHz and 4.08 MHz; 3.92 MHz

C.40 kHz and 4.04 MHz; 3.96 MHz

D.40 kHz and 4.08 MHz; 3.92 MHz

45. The second-harmonic **component in the output** of a transistor amplifier, without feedback, is B_2. The second **harmonic component**, with negative feedback B_2' is equal to (where A= amplifier gain and **β= feedback factor**).

A. $\frac{B_2}{1 + A\beta}$

B. $\beta_2(1 + A\beta)$

C. $\frac{B_2}{\beta}$

D $\frac{B_2}{A\beta}$

46. Consider the following statements

i. Two identical 2nd order Butterworth LP filters when connected in cascade will make a 4th order Butterworth LP filter.
ii. A high pass 2nd order filter will exhibit a peak if Q exceeds certain value.
iii. A band pass filter cannot be of order one.
iv. A network consists of an amplifier of real gain A and aβ network in cascade with each other. The network will generate sinusoidal oscillations if the p network is a first order LP filter.

Which of the above statements are correct?

A. i and ii
B. ii and iii
C. iii and iv
D. i and iv

47. The following switching functions are to be implemented using a Decoder:

$f_1 = \sum m(1,2,4,8,10,14)$

$f_2 = \sum m(2,5,9,11)$

$f_3 = \sum m(2,4,5,6,7)$

The minimum configuration of the decoder should be

A. 2- to-4 lines
B. 3-to-8 lines
C. 4-to-16 lines
D. 5-to-32 lines

48. D input of a clocked D-flip flop receives an input $A \oplus Q_n$ where A is an external logic input and Q_n is the output of nth D-FF before the clock appears. The circuit works as

A. EX-OR gate
B. T-FF
C. D-FF
D. JK-FF

49. A 32 kB RAM is formed by 16 numbers of a SRAM IC. IF each IC needs 14 address bits, what is the IC capacity?

A. 32 kbits
B. 16 kbits
C. 8 kbits
D. B. 4 kbits

50. In a 3-input CMOS NAND gate, the substrate terminals of NMOS transistors are grounded (lowest potential available in the circuit) and the substrate terminals of PMOS transistors are connected to V_{DD} (maximum positive potential in the circuit). Which of the following transistors may suffer in this circuit from body bias effect?

A. 2 NMOS transistors
B. 2 PMOS transistors
C. 1 NMOS transistors
D. 1 PMOS transistors

PART – II

Answer ANY TWO of the following: **(25x2=50)**

1. (a) A 50 MHz carrier delivers 100 W power to a load. The carrier is now frequency modulated by a 1 kHz modulating signal causing a maximum frequency deviation of 6 kHz. This FM modulated signal is now coupled to the load through an ideal band-pass filter with 50 MHz center frequency and a variable bandwidth. Calculate the power delivered to the load when the filter bandwidth is

(i) 1 kHz

(ii) 2.1 kHz

(iii) 12.5 kHz

(iv) 14.5 kHz (v) 20.2 kHz

Comment on the results. Given:

$$J_0(6)=0.1506; J_1(6)=-0.2767; J_2(6)=-0.2429; J_3(6)=0.1148; J_4(6)=0.3576; J_5(6)=0.3621$$

$$J_6(6)=0.2458; J_7(6)=0.1296; J_8(6)=0.0565; J_9(6)=0.0212; J_{10}(6)=0.006$$

(b) Find the output of the matched filter and determine the maximum value of $(S/N)_0$, if the input $s(t)$ is a rectangular pulse of amplitude A and duration T.

2. (a) Consider a CMOS inverter biased at $V_{DD}=5V$ with transistor parameters of $K_N=K_P$ and $V_{TN}=-V_{TP}\approx 1V$. Then consider another CMOS inverter biased at $V_{DD}=10V$ with the same transistor parameters. Determine critical voltages on the voltage transfer curve of the CMOS inverter.

(b) An amplifier with an open loop voltage gain of 500 delivers 10 W of output power at 5% second harmonic distortion when the input signal is 5mV. If 20 dB negative feedback is applied and output power must remain 10W, determine

i. the required input signal strength
ii. the percent second harmonic distortion

3. Draw the circuit of a 2-input TTL totempole output NAND gate with the help of four transistors (multi-emitter, phase splitter, and totempole amplifier transistors).

i. Explain the function of multi-emitter transistor. What is the limitation of using back to back diodes in place of multi-emitter transistors?
ii. Explain the function of protecting diodes connected to multi-emitter transistor.
iii. Why the output of these gates cannot be wire-ANDed?
iv. Why this logic circuit is faster than open collector logic circuit?

4. Binary antipodal signals are used to transmit information over an AWGN channel. The prior probabilities for the two input symbols are $\frac{1}{3}$ and $\frac{2}{3}$.

i. Determine the optimum maximum likelihood decision rule for the detector.

ii. Determine the average probability of error as a function of $\frac{E_b}{N_0}$.

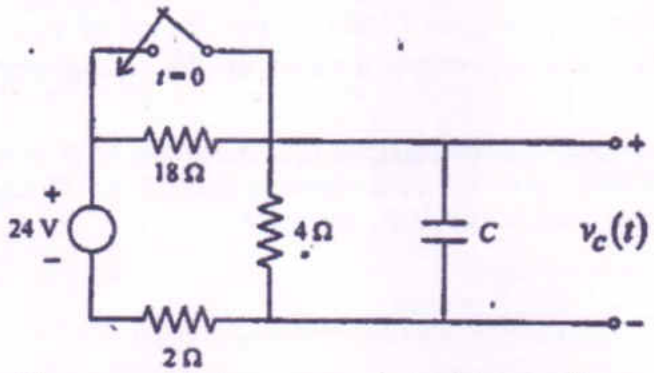
5. (a) Write a program to count from 0 to 20H with a delay of 100 m-sec between each count. After the count reaches 20H, the counter should reset itself and repeat the sequence. Use register pair DE as a delay register. Show your calculations to set up 100 m-sec delay. The clock period is 325.5 n-secs.

(b) A list of 10 integers (both even and odd) are stored in a memory. Write an assembly language program of 8085 to separate even and odd numbers and store them separately.

PART- III

Attempt ANY FIVE of the following questions: **(10x5=50)**

1. Find the value of capacitor C in the circuit shown below, if the voltage across the capacitors is $v_c(t) = 16 - 12e^{-0.6t}$ for t>0 and the switch which was initially open is closed at t=0. The circuit had attained steady state before closing of the switch.



2. Design a counter that has a repeated sequence of six states as given in the table below:

Count Sequence		
A	B	C
0	0	0
0	0	1
0	1	0
1	0	0
1	0	1
1	1	0

3. A uniform linear array of 16 elements has a quarter wavelength spacing between successive elements and a progressive phase difference of α. Determine its normalized array factor, half power beam width, directivity, if $\alpha = -90°$ and what happens to these it $\alpha = 0°$.

4. Draw the low-frequency small-signal models of FET and bipolar junction transistor and compare the two models. Justify the statement that FET is a much more ideal amplifier than the bipolar junction transistor at low frequencies.

5. Realize the following gates using CMOS static gates. Explain the operation with the truth table:

   i. $Y = \left(\overline{A+B}\right)$

   ii. $Y = A \oplus B$

6. For a microwave link, define all the components contributing to system gain. Determine system gain for a microwave link operating at 1.8 GHz carrier frequency. Each station has a 2.4m diameter parabolic antenna fed by 100m of air-filled coaxial cable. The distance between station is 40 km. A reliability objective of 99.99% is desired. The terrain is smooth, and climate is humid.

   Assume feeder loss= 10.8 dB, branching loss= 4 dB and gain of each antenna= 31.2 dB.

7. Show the spatial variations of electric and magnetic fields for TE_{10} mode in a rectangular waveguide. Obtain expression for the cut-off frequencies, propagation constant and phase velocity.

8. Design a second-order active Band-pass filter with a mid-band gain of 33.98 dB, a center frequency of 200 Hz and a 3-dB bandwidth of 20 Hz. Use capacitors of 0.1 μF value. Draw the response of the filter.