

**Date** : October 11, 2025  
**Total Marks** : 100  
**Writing Time** : 150 minutes (2.5 hours)  
**Reading Time** : 15 minutes (prior to writing time)

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
  - **SECTION A** has two parts:  
Part I - 30 Multiple Choice Questions  
Part II - 4 Short Answer Questions  
  
All questions under SECTION A are COMPULSORY.
  - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions of your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part in a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **7 printed pages**, including this instruction page.

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## SECTION A

## PART I: Multiple Choice Questions (30 marks)

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. The forbidden energy gap in semiconductors depends on:
  - a) Temperature
  - b) Doping concentration
  - c) Applied voltage
  - d) Crystal structure
2. A Zener diode is primarily used as:
  - a) A rectifier
  - b) A voltage regulator
  - c) An amplifier
  - d) A switch
3. The current gain ( $\beta$ ) of a BJT in common-emitter mode is given by:
  - a)  $\frac{I_c}{I_b}$
  - b)  $\frac{I_e}{I_b}$
  - c)  $\frac{I_b}{I_c}$
  - d)  $\frac{I_e}{I_c}$
4. In a JFET, the drain current is controlled by:
  - a) Gate voltage
  - b) Drain voltage
  - c) Source voltage
  - d) Channel resistance
5. The ripple factor of a full-wave rectifier is:
  - a) 0.482
  - b) 1.21
  - c) 0.236
  - d) 1.11
6. AM demodulation is done using:
  - a) Envelope detector
  - b) Phase-locked loop (PLL)
  - c) Frequency discriminator
  - d) Schmitt trigger
7. Given a signal  $x = [1, 2, 1, 0]$ , what is the correct way to compute its 2-sided FFT in MATLAB?
  - a)  $x = \text{fft}(x)$
  - b)  $x = \text{fft}(x, 4)$
  - c)  $x = \text{abs}(\text{fft}(x))$

- d) `x = fftshift(fft(x))`
8. To design a 4<sup>th</sup>-order Butterworth bandpass filter with passband 100=300 Hz ( $f_s = 1000$  Hz), which code is correct?
- a) `[b, a] = butter(4, [100 300]/1000, 'bandpass');`
  - b) `[b, a] = butter(2, [100 300]/500, 'bandpass');`
  - c) `[b, a] = butter(4, [100 300]/500, 'bandpass');`
  - d) `[b, a] = butter(4, [100 300], 'bandpass');`
9. In PCM, quantization noise can be reduced by:
- a) Increasing the sampling rate
  - b) Increasing the number of bits
  - c) Decreasing bandwidth
  - d) Using companding
10. Which digital modulation scheme is most bandwidth-efficient?
- a) ASK
  - b) FSK
  - c) PSK
  - d) QAM
11. Which MATLAB code snippet is correct to design a low-pass FIR filter with cutoff frequency = 500 Hz, sampling rate = 2000 Hz, order = 20.
- a) `h = fir1(20, 500/(2000/2), 'low');`
  - b) `h = fir1(20, 500/2000, 'high');`
  - c) `h = fir1(20, 500, 'low');`
  - d) `h = fir1(20, [500], 'low');`
12. A JK flip-flop in toggle mode occurs when:
- a)  $J=0, K=0$
  - b)  $J=1, K=1$
  - c)  $J=1, K=0$
  - d)  $J=0, K=1$
13. The number of flip-flops needed for a MOD-10 counter is:
- a) 2
  - b) 3
  - c) 4
  - d) 5
14. Which logic family has the lowest power dissipation?
- a) TTL
  - b) ECL
  - c) CMOS
  - d) RTL
15. The Boolean expression  $A + \overline{A}B$  simplifies to:
- a) A
  - b) B
  - c)  $A + B$

- d)  $A + B$
16. The Fourier transform of a unit impulse function  $\delta(t)$  is:
- 0
  - 1
  - $\infty$
  - $e^{-j\omega t}$
17. A system is linear if it satisfies:
- Homogeneity
  - Superposition
  - Both homogeneity and superposition
  - Time-invariance
18. The Laplace transform of  $e^{-at}u(t)$  is:
- $\frac{1}{s}$
  - $\frac{1}{s+a}$
  - $\frac{1}{s-a}$
  - $\frac{a}{s}$
19. The region of convergence (ROC) of a causal signal is:
- Left-side of the pole
  - Right-side of the pole
  - Entire s-plane
  - A circle
20. The energy of a signal  $x(t) = e^{-2t}u(t)$  is:
- 0.25 J
  - 0.5 J
  - 1 J
  - 2 J
21. The dominant mode in a rectangular waveguide is:
- $TE_{10}$
  - $TE_{20}$
  - $TM_{11}$
  - TEM
22. A parabolic reflector antenna is used for:
- Omnidirectional radiation
  - High directivity
  - Low gain
  - Short-range comms
23. The S-parameter  $S_{11}$  represents:
- Forward gain
  - Input reflection coefficient

- c) Reverse isolation
  - d) Transmission coefficient
24. The frequency range of Ku-band is approximately:
- a) 1–2 GHz
  - b) 4–8 GHz
  - c) 12–18 GHz
  - d) 30–40 GHz
25. A circulator is a \_\_\_\_\_ port device.
- a) 2
  - b) 3
  - c) 4
  - d) 5
26. The gain margin is measured when phase is:
- a)  $0^\circ$
  - b)  $90^\circ$
  - c)  $-180^\circ$
  - d)  $45^\circ$
27. An ideal op-amp has:
- a) Infinite input impedance
  - b) Zero output impedance
  - c) Infinite gain
  - d) All of the above
28. The PID controller improves system response by:
- a) Reducing rise time
  - b) Eliminating steady-state error
  - c) Reducing overshoot
  - d) All of the above
29. The Barkhausen criterion for oscillation requires:
- a)  $|A| = 1$ , phase shift =  $0^\circ$
  - b)  $|A| > 1$ , phase shift =  $180^\circ$
  - c)  $|A| < 1$ , phase shift =  $90^\circ$
  - d)  $|A| = 0$ , phase shift =  $360^\circ$
30. A Schmitt trigger is used for:
- a) Amplification
  - b) Noise immunity in switching
  - c) Frequency multiplication
  - d) Phase shifting

**PART II – Short Answer Questions [20 marks]**

**This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks.**

1. Probability and Statistics (Reliability Engineering). The time to failure (in hours) of a specific electronic component follows an exponential distribution with a mean of 1000 hours. What is the probability that the component will fail before 500 hours?
2. What is the primary purpose of each term in a PID controller? (Proportional, Integral, Derivative)
3. A transmission line with a characteristic impedance  $Z_0 = 50 \Omega$  is terminated with a load  $Z_L = 100 + j50\Omega$ . What is the value of the normalized load impedance? If you were to use a single stub tuner, would you place a shorted or open stub? Why?
4. A linearly polarized electromagnetic wave is incident upon a perfectly conducting ground plane at an angle. What happens to the polarization of the reflected wave? Justify your answer.

**SECTION B: CASE STUDY (50 marks)**

**Choose either CASE I or CASE II from this section. Each case study carries 50 marks.**

**CASE I**

**AI in Telecommunications**

A mobile network operator wants to reduce call drops and improve Quality of Service (QoS) using AI/ML solutions.

- What kind of network data should be collected for training AI models?
- How can AI be used to predict network congestion and reroute traffic in real time?
- Discuss trade-offs between centralized cloud AI vs. edge AI in telecom applications.

**CASE II**

**Satellite Internet for Remote Areas**

An ISP is exploring Low Earth Orbit (LEO) satellites to provide internet in remote mountainous regions.

- Compare the pros and cons of LEO satellite internet vs. terrestrial fixed wireless.
- What key hardware challenges must be solved for user terminals (antennas, tracking, power efficiency)?
- How can latency be minimized to make services comparable to fiber networks?

**TASHI DELEK**