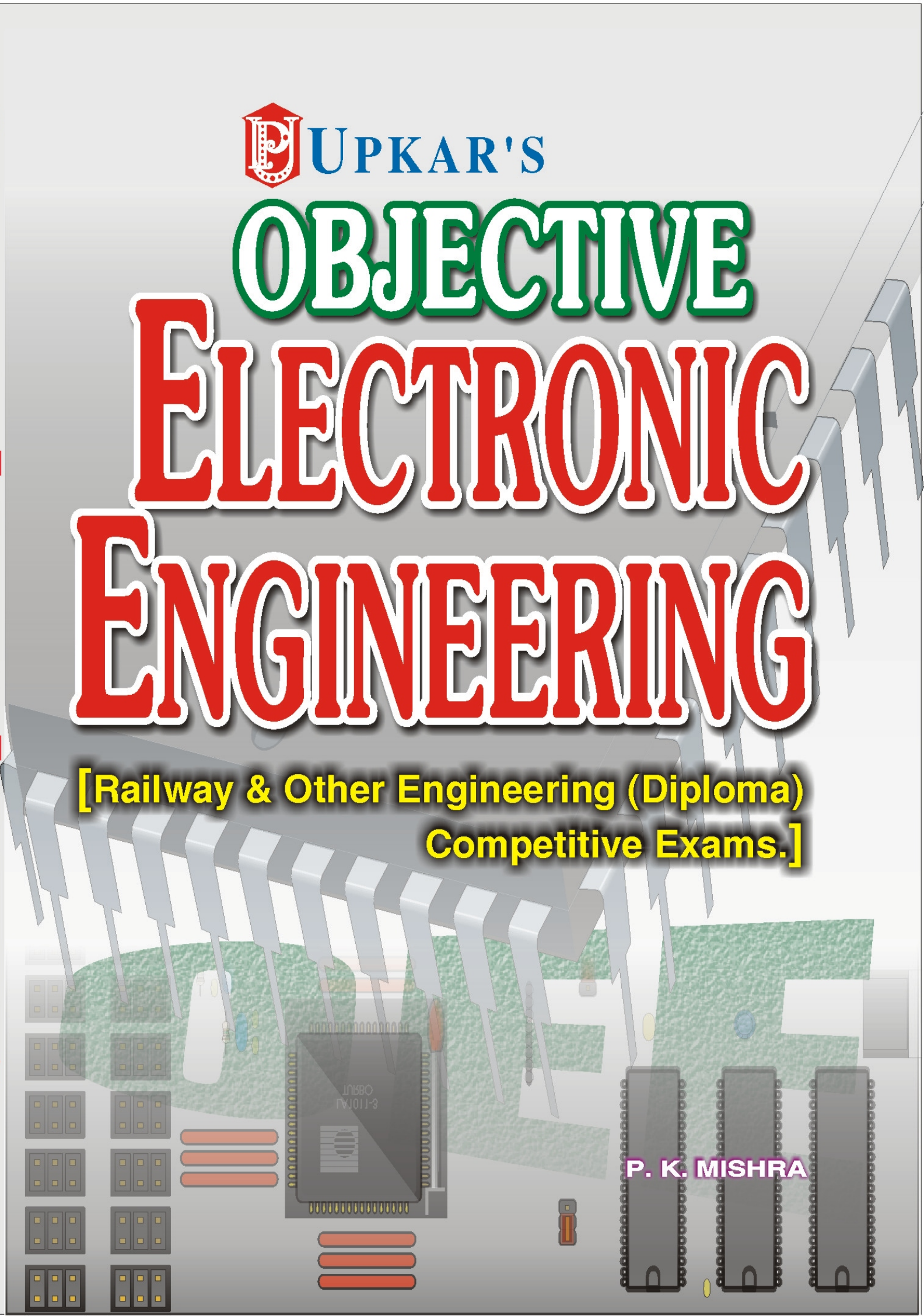
UPKAR'S

OBJECTIVE ELECTRONIC ENGINEERING

[Railway & Other Engineering (Diploma) Competitive Exams.]



P. K. MISHRA

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[For competitive selection examinations of Railway Service, Engineering (diploma) level, State Public Service Commissions, C.P.W.D., P.W.D., Coal India, Irrigation Departments and other equivalent services.]

By

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PREFACE

Success in examinations depends on proper planning of studies and appropriate selection of study materials. The pattern of examinations become tough. This is the reason that a right choice of study materials plays a very important role. This book cover thoroughly all the basics of the whole course as well as present to the examinee a wide spectrum of the multiple choice questions having a huge variety. The author has made a sincere attempt in this direction in the present book. Various unique features of the book are as under for example :

- A brief review of concepts at a glance covering all fundamentals and important conclusions are given at the start of every chapter.
- Chapters are classified under different units.
- Multiple choice questions in every chapter are arranged in a systematic and sequencial way covering the whole text and spectrum of the chapter.
- Answers are provided at the end of every chapters.
- **Model Test Papers** covering the whole syllabus are also provided at the end of the book again with their answers. These papers will prove to be fit for examination and provide a chance to students in assessing their level of preparation.

The present book is self-sufficient in all respects.

I am thankful to my wife Mrs. Rita Mishra who has put a hard labour in reading the proofs thoroughly and pointing out errors and omissions. My sincere thanks are also to publisher Mr. Mahendra Jain who gave me a chance to write this type of books. This edition is a nice form.

Although all attempts have been made to avoid errors and printing mistakes, but omissions are a human weakness and, therefore, constructive suggestions, modifications and errors brought to my notice will be highly appreciated and incorporated in the next edition.

—Pramod Kumar Mishra

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Electronics

Electronics is that branch of science which deals with electron devices *i.e.*, such devices in which conduction by electrons and other charged particles takes place through vacuum, gases or semiconductors. Thus, the science of electronics primarily deals with the study of electron tubes (both vacuum and gas filled tubes), semiconductor diodes and transistors *etc.*, and their applications in electrical circuits.

PART-A

Chapter-1

NETWORKING THEORY
(Circuit Theory)

Circuit—A conducting path through which an electric current either flows or is intended to flow is called a circuit. The various elements of an electric circuit are called parameters (*e.g.,* resistance, inductance and capacitance) these parameters may be distributed or lumped.

Linear Circuit—The circuit whose parameters are constant (*i.e.*, they do not change with voltage or current) is called a linear circuit.

Non-linear Circuit—The circuit whose parameters change with voltage or current is called a non-linear circuit.

Unilateral Circuit—A unilateral circuit is one whose properties or characteristics change with the direction of its operation (*e.g.*, diode, rectifier).

Bilateral Circuit—It is that circuit whose properties or characteristics are same in either direction (*e.g.*, transmission line).

Electric Network—An electric network arises when a number of parameters or electric elements co-exist or combine in any manner or arrangement.

Active Network—An active network is one which contains one or more than one sources of e.m.f.

Passive Network—A passive network is one which does not contain any source of e.m.f.

Node—A node is a junction in a circuit where two or more circuit elements are connected together.

Branch—The part of a network which lies between two junctions is called branch.

Kirchhoff's Law—For complex circuit computations are following two laws first stated by Gutsav R. Kirchhoff (1824-87) are indispensable.

First Law (Point or Current Law)—It states as follows—

"The sum of the current entering a junction is equal to the sum of the currents leaving the junction."

i.e., $\sum$ current entering = $\sum$ currents leaving

Second Law (Mesh or Voltage Law)—It states as follows "The sum of e.m.f. (rise of potential) around any closed loop of circuit equals the sum of the potential drops in that loop."

Considering a rise of potential as positive (+ve) and a drop of potential as negative (–ve) algebraic sum of potential differences (voltages) around a closed loop of a circuit is zero.

$$\sum E - \sum I R \text{ drops} = 0$$

(around closed loop)

$$\sum E = \sum IR$$

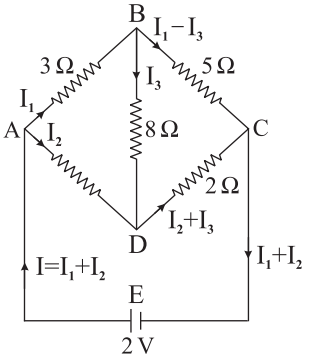
or, $\sum$ potential rises = $\sum$ potential drops

Application of Kirchhoff's Law

Kirchhoff's laws may be employed in the following methods of solving networks—

1. Branch-Current method
2. Maxwell's loop (or mesh) Current method
3. Nodal voltage method.

Example or Application (1)—Determine the current in each of the resistors of the network shown in given figure.



Applying Kirchhoff's law to the various circuits.

Circuit ABDA—

$$-3I_1 - 8I_3 + 4I_2 = 0$$

or, $$3I_1 - 4I_2 + 8I_3 = 0 \quad \ldots(i)$$

Circuit BCDB—

$$-5(I_1 - I_3) + 2(I_2 + I_3) + 8I_3 = 0$$

$$5I_1 - 2I_2 - 151_3 = 0 \quad \ldots(ii)$$

Circuit ADCEA—

$$-4I_2 - 2(I_2 + I_3) + 2 = 0$$

$$3I_2 + I_3 = 0 \quad \ldots(iii)$$

On solving equations (i), (ii) and (iii), we get

$$I_1 = 0{\cdot}283 \text{ A}$$

$$I_2 = 0{\cdot}316 \text{ A}$$

$$I_3 = 0{\cdot}052 \text{ A}.$$

Superposition Theorem

This theorem stated as follows—

"In any network containing more than one sources of e.m.f. the current in any branch is the algebraic sum of a number of individual fictitious currents, each of which is due to the separate action of each source of e.m.f. taken in order, when the remaining sources of e.m.f. are replaced by conductors, the resistances of which are equal to the internal resistances of the respective sources."

The procedure of applying superposition theorem is as follows—

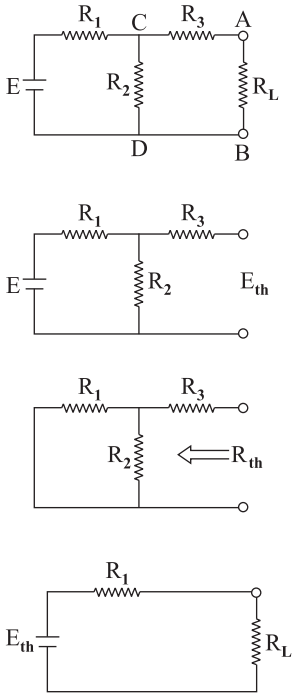
1. Replace all but one of the sources by their internal resistances. If the internal resistance of any source is small as compared to the other resistances present in the network, the source is replaced by a short circuit.

2. Find the currents in different branches by using Ohm's law.

3. Repeat the process using each of the e.m.fs. as the sole e.m.f. each time.

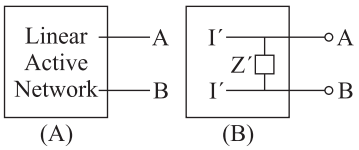
The total current in any branch of the circuit is the algebraic sum of currents due to each source.

Thevenin's Theorem—This theorem states that "For the purpose of determining the current in a resistor R_L, connected across two terminals of a network which contains sources of e.m.f. and resistor, the network can be replaced by a single source of e.m.f. and a series resistor, R_{th}. This e.m.f. E_{th} is equal to potential difference between the terminals of the network when the resistor R, is removed; the resistance of series resistor, R_{th}, is equal to the equivalent resistance of the network with the resistor R removed—



Hence, $$I = \frac{E}{R_L + R_{th}}$$

Nortons Theorem—It states that any linear current active network with output terminals AB as shown in figure (A). A can be replaced by a single source I′ is parallel with a single impedance Z′ as shown below in fig. (B).



The Norton equivalent current source I′ is the current through a short circuit applied to the terminals of the active network. The shunt impedance Z′ is the driving point impedance of the network at the terminals AB when all interval source are set equal to zero.

Hence, given a linear active circuit, the impedance Z′ of the Norton and Thevenin equivalent circuits are identical.

Maximum Power Transfer Theorem

It is stated as follows—

"Maximum power output is obtained from a network when the load resistance is equal to the output resistance of the network as seen from the terminals of the load."

Compensation Theorem

The compensation theorem is particularly useful for the following purpose—

(i) To calculate the sensitivity of a bridge network.

(ii) The analyse those networks where the values of the branch elements are varied and for studying the effect.

This theorem is stated as follows—

If a change, say ΔR is made in the resistance of any branch of a network when the current was originally I, then the change of current at any other point in the network may be calculated by assuming that an e.m.f.—$I \Delta R$ has been introduced into the changed branch while all other sources have their e.m.f.s suppressed and are represented by their internal resistances only."

Reciprocity Theorem

This theorem is stated as follows—

"In any linear bilateral network, if a source of e.m.f. E in any branch produces a current I in any other branch, then the same e.m.f. acting in the second branch would produce the same current I in the first branch."

Milliman's Theorem—This theorem is stated as follows—

"Any number of current sources in parallel may be replaced by a single current source whose current is the algebraic sum of individual source currents and source resistance is the parallel combination of individual source resistances."

Alternating Voltage and Current

Modern alternators produce an e.m.f. which is for all practical purposes sinusoidal (*i.e.*, a sine curve) the equation between the e.m.f. and time being—

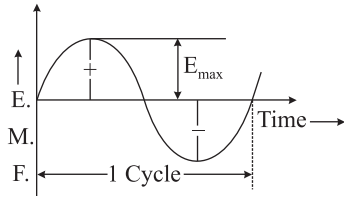
$$\boxed{e = E_{max} \sin \omega t}$$

where, e = instantaneous voltage,

E_{max} = maximum voltage

ωt = angle through which the armature has turned from neutral

Cycle—One complete set of positive and negative values of an alternating quantity is known as cycle. One complete cycle is said to spread over 360° or 2π radian.



Amplitude—The maximum value, positive or negative, of an alternating quantity is known as its amplitude.

Frequency—The number of cycles/second is called the frequency of the alternating quantity. Its unit is hertz (Hz).

Time Period (T)—The time taken by an alternating quantity to complete the cycle is called its time period. Time period is the reciprocal of frequency.

$$\boxed{T = \frac{1}{f} \text{ or } f = \frac{1}{T}}$$

Root Mean Square (R.M.S.) Value—The r.m.s. value of an alternating current is given by that steady (D.C.) current which when flowing through a given circuit for a given time produces the same heat as produced by the alternating current when flowing through the same circuit for the same time.

$$E_{r.m.s.} = E_{max} \times \frac{1}{\sqrt{2}}$$

Average or Mean Value—The average value of an alternating current is expressed by that steady current which transfers across any circuit the same charge as is transferred by that alternating current during the same time.

Reasons for Using Alternating Current (or Voltage) of Sinusoidal Form

The alternating current (or voltage) of Sinusoidal form is normally used because of the following reasons—

(i) Mathematically it is quite simple.

(ii) Its integrals and differentials both are sinusodial.

(iii) It lends itself to vector representation.

(iv) A complex wave form can be analysed into a series of sine waves of various frequencies, and each such component can be dealt with separately.

(v) This wave form is desirable for power generation, transmission and utilisation.

Electrical Wave Filters

Electric networks, which permit unattenuated transmission of electric signals within specified frequency ranges and produce attenuation to suppress the signals outside the specified frequency ranges are known as Electric Wave Filters or Filters.

The filters may be classified as follows—

1. Low pass filter
2. High pass filter
3. Band pass filter
4. Band elimination filter.

OBJECTIVE QUESTIONS

1. Kirchhoff's laws are valid for—
   (A) Both AC and DC only
   (B) AC circuit only
   (C) DC circuit only
   (D) Fully in DC and partially in AC
2. Kirchhoff's laws fail in case of—
   (A) Distributed parameter networks
   (B) Dual networks
   (C) Linear networks
   (D) Non-linear networks
3. Superposition Theorem can be applied only to circuits having—
   (A) Resistive elements
   (B) Passive elements
   (C) Non-linear elements
   (D) Linear bilateral elements
4. The concept on which Superposition Theorem is based on—
   (A) Reciprocity (B) Duality
   (C) Non-linearity (D) Linearity
5. An ideal voltage source should have—
   (A) Large value of e.m.f.
   (B) Small value of e.m.f.
   (C) Zero source resistance
   (D) Infinite source resistance
6. Which of the following is non-linear circuit parameter ?
   (A) Inductance
   (B) Condenser
   (C) Wire wound resistor
   (D) Transistor
7. Kirchhoff's law is applicable to—
   (A) Passive networks only
   (B) AC circuits only
   (C) DC circuits only
   (D) Both AC as well as DC circuits
8. Kirchhoff's law is not applicable to circuits with–
   (A) Lumped parameters
   (B) Passive elements
   (C) Distributed parameters
   (D) Non-linear resistances
9. Which of the following is not a non-linear element ?
   (A) Gas diode (B) Heater coil
   (C) Tunnel diode (D) Electric arc
10. The Superposition Theorem is applicable to—
    (A) Voltage only
    (B) Current only
    (C) Both current and voltage
    (D) Current, voltage and power
11. A terminal where three or more branches meet is known as—
    (A) Node (B) Terminus
    (C) Combination (D) Anode
12. Which of the following is the passive element ?
    (A) Capacitance
    (B) Ideal current source
    (C) Ideal voltage source
    (D) All of the above

13. The peak value of a sine wave is 200 V. Its average value is—
    (A) 127·4 V (B) 141·4 V
    (C) 282·8 V (D) 200 V

14. For a sine wave with peak value I_{max} the *r.m.s.* value is—
    (A) 0·5 I_{max} (B) 0·707 I_{max}
    (C) 0·9 I_{max} (D) 1·415 I_{max}

15. In a series resonant circuit the impedance of the circuit is—
    (A) Minimum (B) Maximum
    (C) Zero (D) None of these

16. Power factor of the following circuit will be zero—
    (A) Resistance (B) Inductance
    (C) Capacitance (D) Both (B) and (C)

17. Power factor of the following circuit will be zero—
    (A) Inductance (B) Capacitance
    (C) Resistance (D) Both (A) and (B)

18. In a circuit containing R, L and C power loss can take place in—
    (A) C only (B) L only
    (C) R only (D) All of these

19. Power factor of electric bulb is—
    (A) Zero (B) Lagging
    (C) Leading (D) Unity

20. Power factor of magnetising component of current of a transformer is—
    (A) 0·8 lag (B) 0·8 lead
    (C) Zero (D) Unity

21. The purpose of a parallel circuit resonance is to magnify—
    (A) Current (B) Voltage
    (C) Power (D) Frequency

22. In an A.C. circuit power is dissipated in—
    (A) Resistance only
    (B) Inductance only
    (C) Capacitance only
    (D) None of the above

23. In a parallel R-C circuit, the current always …… the applied voltage.
    (A) laga
    (B) leads
    (C) remains in phase with
    (D) None of the above

24. The unit of frequency of an A.C. signal is—
    (A) Cycle (B) Hertz
    (C) Hertz/sec (D) Cycle-sec

25. While drawing vector diagram for a series circuit, the reference vector is—
    (A) Voltage (B) Current
    (C) Power (D) Phase angle

26. In an A.C. circuit I sin ϕ is called—
    (A) Active component
    (B) Wattless component
    (C) Both (A) and (B)
    (D) None of the above

27. In a series resonant circuit, the impedance of the circuit is—
    (A) Maximum (B) Minimum
    (C) Zero (D) Infinite

28. The value of operator j^2 is equal to—
    (A) Zero (B) + 1
    (C) – 1 (D) $\sqrt{-1}$

29. A resonance curve for a series circuit is a plot of frequency *versus*—
    (A) Current (B) Voltage
    (C) Impedance (D) Reactance

30. Higher the Q of a series circuit—
    (A) Broader its resonance curve—
    (B) Narrower its pass band
    (C) Greater its band width
    (D) Sharper its resonance

31. Selectivities of different resonance circuits are compared in terms of their—
    (A) Impedances (B) Reactances
    (C) Frequencies (D) Bandwidths

32. The ratio of bandwidth to the resonance frequency is called the …… of the circuit.
    (A) impedance (B) susceptance
    (C) quality factor (D) selectivity

33. The dual of a loop is……
    (A) twig (B) node pan
    (C) mesh (D) tree

34. The series element of a band stop filter is—
(A) Capacitive
(B) Inductive
(C) Parallel combination of L and C
(D) Series combination of L and C

35. The dual of a link is—
(A) Twig (B) Node
(C) Loop (D) Tree branch

36. The reflection co-efficient of the simplest standing ware is—
(A) – 1 (B) 1
(C) Zero (D) Infinity

37. The shunt element in a bond pass filter is—
(A) Capacitance
(B) Inductive
(C) Parallel combination of L and C
(D) Series combination of L and C

38. The phase velocity v in a transmission line is—
(A) LC (B) $\sqrt{C/L}$
(C) $\sqrt{L/C}$ (D) $1/\sqrt{LC}$

39. Which of the following frequencies has the greatest period ?
(A) 20 Hz (B) 200 Hz
(C) 20 kHz (D) 200 kHz

40. In electrical appliances the power rating is determined by—
(A) Voltage (B) Current
(C) Iron loss (D) Copper loss

41. The double integration of a unit step function results in—
(A) A unit doublet
(B) A unit parabola
(C) A unit ramp function
(D) A unit impulse

42. The current in a chemical cell is a movement of—
(A) Positive ions only
(B) Negative ions only
(C) Positive hole
(D) Positive and negative ions

43. Inverter is a circuit which transforms—
(A) A.C. to D.C. (B) A.C. to A.C.
(C) D.C. to A.C. (D) D.C. to D.C.

44. Power transform of an even periodic function contains only—
(A) A constant (B) Odd harmonics
(C) Sine terms (D) None of these

45. The parallel resonant circuit magnifies—
(A) Voltage (B) Current
(C) Power (D) None of these

46. The double energy transients occur in the—
(A) Pure Inductive Coil
(B) R–L Circuit
(C) R–C Circuit
(D) R–L–C Circuit

47. The time constant of an R–C circuit increases if the value of resistance is—
(A) Increased
(B) Decreased
(C) Either of the above
(D) None of the above

48. The voltage source in series resonance circuit is—
(A) Zero (B) Low
(C) High (D) None of these

49. The double energy transients occur in the …… circuit.
(A) Pure Inductive (B) R–L
(C) R–C (D) R–L–C

50. The shunt element in a band pass filter is—
(A) Inductive
(B) Capacitive
(C) Shunt combination of L and C
(D) Series combination of L and C

51. The series element in a band pass filter is—
(A) Inductive
(B) Capacitive
(C) Series combination of L and C
(D) Shunt combination of L and C

52. The power factor for a circuit is of the order of—
(A) 0·2 (B) 0·4
(C) 0·6 (D) 0·8

53. A capacitor at $t = 0^+$ with zero initial current acts as—
(A) Current source (B) Voltage source
(C) Open circuit (D) Short circuit

54. The resistance of a wire depends on its—
(A) Colour
(B) Humidity
(C) Number of neutrons
(D) Temperature

55. Fouriers series expansion of an odd periodic function contains—
(A) Sine terms only
(B) Cosine term only
(C) Both (A) and (B)
(D) None of the above

56. When Q of a coil increases, its power factor—
(A) Decreases
(B) Increases
(C) Remains unaltered
(D) Any of the above

57. In a linear network if all the n sources are multiplied by a constant z, then the response gets multiplied by—
(A) z (B) z/n
(C) $n/2$ (D) $2/n$

58. A planar graph has six branches and three meshes. Then the number of nodes is—
(A) Two (B) Three
(C) Four (D) Six

59. The double integration of a unit step function results in a unit—
(A) Parabola (B) Impulse
(C) Ramp function (D) None of these

60. An impedance is capacitive if—
(A) only if $X_L = 0$ (B) $X_L < X_C$
(C) $X_L > X_C$ (D) $R = 0$

61. To increase the Q-factor of an inductor it is wound with—
(A) Longer wire (B) Coiled coil wire
(C) Thicker wire (D) Thinner wire

62. Zero of a network is the critical frequency at which network function becomes—
(A) Zero (B) Unity
(C) Sinusoidal (D) Infinity

63. Fourier transform of even periodic functions contains only—
(A) Sine terms
(B) Odd harmonics
(C) A constant
(D) None of the above

64. An inductor at $t = \infty$ with zero initial current acts as—
(A) Open circuit (B) Short circuit
(C) Voltage source (D) Current source

65. The series element of a prototype high pass filter is—
(A) Inductive (B) Capacitive
(C) Resistive (D) None of these

66. Laplace transform of e^{at} is—
(A) a/s (B) $1/(s - a)$
(C) $1/(s + a)$ (D) $1/s$

67. The capacitance of a prototype high pass filter is given by—
(A) $4\pi f_c R_0$ (B) $f_c/4\,\pi\, R_0$
(C) $1/4\pi f_c R_0$ (D) $4\pi f_c/R_0$

68. A closed path made by several branches of the network is known as—
(A) Branch (B) Loop
(C) Circuit (D) Junction

69. The Q of a series R–L–C circuit is equal to the……
(A) impedance
(B) resonant frequency
(C) voltage gain
(D) band width

70. A capacitor stores energy in—
(A) An electromagnetic field
(B) A magnetic field
(C) Dielectric dipole
(D) All of the above

71. The superposition theorem requires as many circuits to be solved as there are—
(A) Nodes (B) Sources
(C) Meshes (D) None of these

72. In a R–L series circuit time constant is given by—
(A) L/R (B) LR
(C) LR^2 (D) L^2R

73. Rheostat are usually rated in—
(A) Amperes (B) Volts and amperes
(C) Watts and volts (D) Watts and amperes

74. In a parallel resonance circuit the current is given by—
(A) V/R (B) VR/LC
(C) V/RC (D) $\frac{V}{L/CR}$

75. The voltage source in series resonance circuit is—
(A) Zero resistance (B) Low resistance
(C) High resistance (D) None of these

76. A capacitor behaves to D.C. as—
(A) Short circuit
(B) An open circuit
(C) It behaves to A.C.
(D) None of the above

77. A circuit is called complex if—
(A) Electrons can flow
(B) A batterry is present
(C) Electrons are present
(D) A voltage difference exits

78. Which of the following is not a non-linear element ?
(A) Transistor (B) Heater coil
(C) Diode (D) Electric arc

79. The frequency of domestic power supply in India is—
(A) 200 Hz (B) 100 Hz
(C) 60 Hz (D) 50 Hz

80. The negative maximum of a cosine wave occurs at—
(A) 30° (B) 45°
(C) 90° (D) 180°

81. The r.m.s. value of pure cosine function is—
(A) 0·5 of peak value
(B) 0·707 of peak value
(C) Same as peak value
(D) Zero

82. For the full wave rectified sine wave the r.m.s. value is—
(A) $0{\cdot}7071_{max}$ (B) $0{\cdot}6361_{max}$
(C) $0{\cdot}3181_{max}$ (D) Zero

83. The time constant of a series R–C circuit is given by—
(A) R/C (B) RC^2
(C) RC (D) R^2C

84. Which of the following circuit components oppose the change in the circuit voltage ?
(A) Inductance (B) Capacitance
(C) Conductance (D) Resistance

85. The r.m.s. value of sinusoidal A.C. current is equal to its value at an angle of..... degrees.
(A) 90° (B) 60°
(C) 45° (D) 30°

86. When two waves are in phase they gave peak values at an interval of—
(A) 180° (B) 120°
(C) 90° (D) None of these

87. For a frequency of 200 Hz the time period will be—
(A) 0·05 s (B) 0·005 s
(C) 0·0005 s (D) 0·5 s

88. An ideal current source has zero—
(A) Internal conductance
(B) Internal resistance
(C) Voltage on no load
(D) Ripple

89. A terminal where three or more branches meet is known as—
(A) Combination (B) Terminus
(C) Anode (D) Node

90. A closed path made by several branches of the network is known as—
(A) Circuit (B) Branch
(C) Junction (D) Loop

91. Which of the following has non-linear V-I characteristics ?
(A) Vacuum diode (B) Transistor
(C) Filament bulb (D) All of these

92. Kirchhoff's law is applicable to—
(A) A.C. circuits only
(B) D.C. circuits only
(C) A.C. as well on D.C. circuit only
(D) Passive networks only

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