Tranformer

Definition and Basic Principle

Transformer: A transformer is a static electrical device that transfers electrical energy between two or more circuits through electromagnetic induction.

Basic Principle: It works on the principle of mutual induction, where a varying current in the primary coil generates a varying magnetic field that induces a varying electromotive force (EMF) in the secondary coil.

Construction

1. Core: Made of laminated iron or ferrite to minimize eddy current losses.

2. Windings

  Primary Winding: Connected to the input voltage source.

  Secondary Winding: Connected to the output load.

Working

Mutual Induction: A time-varying current in the primary winding creates a time-varying magnetic field, which induces a voltage in the secondary winding according to Faraday's law of electromagnetic induction.

Types of Transformers

1. Step-Up Transformer: Increases voltage from primary to secondary (more turns in secondary winding).

2. Step-Down Transformer: Decreases voltage from primary to secondary (fewer turns in secondary winding).

Transformer Equation

$$\frac{V_P}{V_S} = \frac{N_P}{N_S}$$

$$\frac{I_P}{I_S} = \frac{N_S}{N_P}$$

Where V_P and V_S are the primary and secondary voltages, N_P and N_S are the number of turns in the primary and secondary coils, and I_P and I_S are the primary and secondary currents.

Efficiency

Efficiency (η): Ratio of output power to input power.

$$\eta = \frac{P_{OUT}}{P_{IN}} \times 100\%$$

Losses: Include core losses (hysteresis and eddy current losses) and copper losses (I^2R losses in windings).

Applications

- **Power Distribution**: Stepping up voltage for transmission and stepping down voltage for distribution.

- **Isolation**: Electrical isolation between circuits.

- **Impedance Matching**: In audio and radio-frequency applications.

Important Concepts

Turns Ratio: Determines the voltage transformation ratio.

Core Saturation: Occurs when the core cannot magnetically accommodate further increase in magnetic flux.

Load Regulation: Ability of the transformer to maintain constant secondary voltage under varying load conditions.

Sample Problems

1. **Voltage Calculation**: Given N_p and N_s, calculate V_s using the transformer equation.
2. **Current Calculation**: Given primary current and turns ratio, calculate secondary current.
3. **Efficiency Calculation**: Given input and output power, calculate transformer efficiency.

Example Questions

1. Calculation Based:

➢ A transformer has 500 turns on the primary coil and 200 turns on the secondary coil. If the primary voltage is 100V, find the secondary voltage.

➢ A step-down transformer reduces the voltage from 220V to 110V. If the primary current is 2A, what is the secondary current?

2. Conceptual

➢ Explain the significance of laminating the core of a transformer.

➢ Why are transformers rated in kVA and not in kW?

By understanding these concepts and practicing related problems, you can be well-prepared to tackle transformer-related.

1. What is the primary function of a transformer?

   a) To convert AC to DC

   b) To convert DC to AC

   c) To increase or decrease voltage

   d) To store electrical energy

2. What device is used to change the voltage in a transformer?

   a) Capacitor

   b) Diode

   c) Transformer

   d) Resistor

3. In an ideal transformer, which of the following remains constant?

   a) Voltage

   b) Current

   c) Power

   d) None of the above

4. What is the main difference between an autotransformer and a conventional transformer?

   a) Autotransformers have only one winding*

   b) Conventional transformers have only one winding

   c) Autotransformers are used for AC, conventional for DC

   d) Conventional transformers are smaller in size

5. Which of the following is not a type of transformer core?

   a) Iron core

   b) Ferrite core

   c) Copper core

   d) Air core

6. The efficiency of an ideal transformer is:

   a) 0%

   b) 50%

   c) 100%

   d) Depends on the load

7. In a step-up transformer, the number of turns in the primary coil is _____ the number of turns in the secondary coil.

   a) Greater than

   b) Less than

   c) Equal to

   d) Unrelated to

8. What happens to the current in a step-up transformer compared to the input current?

   a) Increases

   b) Decreases

   c) Remains the same

   d) Depends on the load

9. In a step-down transformer, the voltage across the secondary coil is _____ the voltage across the primary coil.

   a) Greater than

   b) Less than

   c) Equal to

   d) Unrelated to

10. The function of the transformer core is to:

   a) Increase voltage

   b) Decrease voltage

   c) Increase magnetic field

   d) Decrease magnetic field

11. Which of the following materials is commonly used as a core material in transformers?

   a) Aluminum

   b) Copper

c) Silicon steel

   d) Silver

12. The phenomenon of self-induction is associated with:

   a) Transformers

   b) Capacitors

   c) Inductors

   d) Resistors

13. Which of the following equations represents the voltage transformation ratio of a transformer?

   a) $Vp/Vs = Np/Ns$
   b) $Vs/Vp = Np/Ns$
   c) $Vp \times Vs = Np \times Ns$
   d) $Vp - Vs = Np - Ns$

14. In a transformer, the power output is:

   a) Always less than the power input

   b) Always greater than the power input

   c) Equal to the power input

   d) Sometimes greater and sometimes less than the power input

15. Which of the following factors does not affect the efficiency of a transformer?

   a) Core material

   b) Operating frequency

   c) Ambient temperature

   d) Length of the connecting wires

16. What type of loss in a transformer is reduced by using a laminated core?

   a) Copper loss

   b) Eddy current loss

   c) Hysteresis loss

   d) Flux leakage

17. Which component of a transformer is primarily responsible for energy transfer between circuits?

   a) Core

   b) Windings

   c) Insulation

   d) Cooling system

18. How is the efficiency of a transformer generally expressed?

   a) Ratio of input power to output power

   b) Ratio of output power to input power

   c) Difference between input and output power

   d) Sum of input and output power

19. What is the main reason for using oil in a transformer?

   a) To insulate the windings

   b) To cool the transformer

   c) To increase the voltage

   d) To decrease the current

20. What does the turns ratio of a transformer determine?

   a) The frequency of the output voltage

   b) The power of the output voltage

   c) The voltage changes between primary and secondary coils

   d) The current change between primary and secondary coils

21. In a transformer, what is the purpose of the laminated core?

   a) To increase the magnetic field strength

   b) To reduce copper losses

   c) To improve insulation

   d) To reduce eddy current losses

22. Which of the following statements is true about a step-down transformer?

   a) The secondary voltage is higher than the primary voltage

   b) The secondary current is lower than the primary current

   c) The secondary voltage is lower than the primary voltage

   d) The number of turns in the secondary coil is more than in the primary coil

23. What kind of transformer is used to measure high voltages?

   a) Power transformer

   b) Autotransformer

   c) Potential transformer

   d) Current transformer

24. What kind of transformer is used to measure high currents?

   a) Power transformer

   b) Autotransformer

   c) Potential transformer

   d) Current transformer

25. In an ideal transformer, if the primary winding has 100 turns and the secondary winding has 200 turns, what is the voltage ratio (Vp:Vs)?

   a) 2:1

   b) 1:2

   c) 1:1

   d) 2:3

26. If the primary coil has 1000 turns and the secondary coil has 100 turns, the transformer is:

a. Step-up
b. Step-down
c. Isolating
d. Inverting

27. The primary principle on which a transformer operates is:
a. Ohm's Law
b. Coulomb's Law
c. Mutual Induction
d. Faraday's Law

28. The efficiency of a transformer is typically:

a. Less than 50%
b. 50%
c. 70%
d. Greater than 90%

29. The core of a transformer is laminated to reduce:

a. Hysteresis loss
b. Eddy current loss
c. Copper loss
d. Magnetostriction

30. For a transformer with a turns ratio of 10:1, if the primary voltage is 220V, the secondary voltage is:

a. 2200V
b. 22V
c. 110V
d. 22kV

31. In a transformer, the primary and secondary windings are:

a. Physically connected
b. Electrically connected

c. Magnetically connected
d. Mechanically connected

32. If a transformer has 100 turns on the primary coil and 50 turns on the secondary coil, the primary voltage is 240V. The secondary voltage is:

a. 120V
b. 480V
c. 60V
d. 240V

33. Which of the following is not a type of transformer loss?

a. Core loss
b. Copper loss
c. Dielectric loss
d. Friction loss

34. A transformer is rated in:

a. kW
b. kVA
c. kWh
d. Amperes

35. The main purpose of using oil in a transformer is:

a. To lubricate the windings
b. To insulate and cool the windings
c. To increase voltage
d. To decrease current

36. The voltage per turn in the primary and secondary windings of a transformer is:
a. Different
b. Same
c. Dependent on the core material
d. Dependent on the frequency

37. In an ideal transformer, the power transferred from primary to secondary is:

   a. Increased
   b. Decreased
   c. Equal
   d. Zero

38. The function of the conservator in a transformer is to:

   a. Maintain constant voltage
   b. Maintain constant current
   c. Provide space for oil expansion
   d. Protect against short circuits

39. Which of the following materials is typically used for transformer cores?

   a. Copper
   b. Aluminum
   c. Silicon steel
   d. Plastic

40. When the load on the secondary side of a transformer increases, the primary current:

   a. Decreases
   b. Remains the same
   c. Increases
   d. Fluctuates randomly

41. The primary winding of a transformer is connected to:

   a. Load
   b. Source
   c. Ground
   d. Capacitor

42. Which type of transformer is used to connect circuits of different impedances?

   a. Isolation transformer
   b. Autotransformer
   c. Step-up transformer
   d. Impedance matching transformer

43. If the primary current in a transformer is 2A and the turns ratio is 1:5, the secondary current is:

   a. 10A
   b. 0.4A
   c. 2A
   d. 1A

44. The leakage flux in a transformer depends on:

   a. The frequency of operation
   b. The load current
   c. The voltage applied
   d. The winding resistance

45. : A transformer has 500 turns in the primary coil and 100 turns in the secondary coil. If the primary voltage is 240 V, what is the secondary voltage?

   Solution:

   - $Vs = Vp \times \frac{Ns}{Np}$
   - $Vs = 240 \times \frac{100}{500}$
   - $Vs = 240 \times 0.2$
   - $Vs = 48$ V

46. A step-down transformer reduces the voltage from 220 V to 55 V. If the primary coil has 880 turns, how many turns are there in the secondary coil?

Solution:

- $\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p}$

- $\dfrac{55}{220} = \dfrac{N_s}{880}$

- $\dfrac{1}{4} = \dfrac{N_s}{880}$

- $N_s = 880 \times \dfrac{1}{4}$

- $N_s = 220$ turns

47. A transformer has a primary current of 2 A and a primary voltage of 110 V. If the secondary voltage is 220 V, what is the secondary current assuming an ideal transformer?

Solution:

- $P_p = P_s$ (In an ideal transformer, Power is conserved)

- $V_p \times I_p = V_s \times I_s$

- $110 \times 2 = 220 \times I_s$

- $220 = 220 \times I_s$

- $I_s = 1$ A

48. A transformer is designed to convert 120 V to 12 V. If the primary coil has 600 turns, how many turns should the secondary coil have?

Solution:

- $\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p}$

- $\dfrac{12}{120} = \dfrac{N_s}{600}$

- $\dfrac{1}{10} = \dfrac{N_s}{600}$

- $N_s = 600 \times \dfrac{1}{10}$

- $N_s = 60$ turns

49. A transformer has a power output of 1000 W and an efficiency of 95%. What is the power input?

Solution:

- Efficiency $\eta = \dfrac{P_{out}}{P_{in}} \times 100$

- $95 = \dfrac{1000}{P_{in}} \times 100$

- $P_{in} = \dfrac{1000 \times 100}{95}$

- $P_{in} = \dfrac{100000}{95}$

- $P_{in} \approx 1052.63$ W