# THE IDEAL TRANSFORMER

In the following statements one of the suggested answers is best. Place the identifying letter on your answer sheet.

The core flux in a double wound transformer cuts the -

a) primary winding only
b) secondary winding only
c) primary winding on one half cycle and the secondary winding on the other halfcycle
d) primary and secondary windings simultaneously

The secondary voltage of a transformer is produced by -

a) electrostatic induction
b) current conduction
c) mutual induction
d) self induction

The number of primary winding turns on a transformer is determined by the -

a) supply frequency, voltage and core flux
b) primary current and voltage
c) impedance of the secondary load
d) frequency of the supply only

If a double wound transformer having a voltage ratio of 2:1 is supplied with a 50Hz sine wave to the primary winding, the frequency of the secondary output will be -

a) 25Hz sine wave
b) 25Hz distorted wave
c) 50Hz sine wave
d) 50Hz distorted wave

The number of primary turns on a transformer is governed by the -

a) secondary current
b) primary current
c) primary voltage
d) required ratio of transformation

In an isolation transformer the -

a) secondary voltage is greater than the primary voltage
b) primary voltage is greater than the secondary voltage
c) primary is equal to the secondary voltage
d) primary and secondary voltages are connected to oppose one another

In a step-down transformer the -

    a) secondary voltage is greater than the primary voltage
    b) <mark>primary voltage is greater than the secondary voltage</mark>
    c) primary is equal to the secondary voltage
    d) primary and secondary voltages are connected to assist one another

If the secondary current of a voltage transformer is greater than the primary current, the transformer is known as a/an -

    a) isolation transformer
    b) <mark>step-down transformer</mark>
    c) step-up transformer
    d) auto transformer

The transfer of energy from primary to secondary of a transformer is achieved via -

    a) self induction
    b) electrostatic induction
    c) current conduction
    d) <mark>mutual induction</mark>

As secondary load is increased, the primary current of a transformer -

    a) decreases in proportion to the load
    b) remains constant
    c) <mark>increases</mark>
    d) decreases by a small amount

*SECTION B*

Blank spaces in the following statements represent omissions. Write the appropriate information on your answer sheet.

Two coils having mutual inductance are said to be_____(1)_____.

<mark>Magnetically coupled</mark>

A transformer that has more turns on the secondary winding than the primary winding is called a_____(2)_____transformer.

<mark>Step up</mark>

A transformer in which the secondary voltage is less than the primary voltage is called a _____(3)_____transformer.
<mark>Step down</mark>

A transformer in which the primary and secondary voltages are equal, is called an _____(4)_____transformer.
<mark>Isolation</mark>

Because a transformer has no moving parts it is known as a_____(5)_____machine.

<mark>Static</mark>

The primary winding of a transformer is acted upon by two voltages, the applied voltage eand the emf of_____(6)_____induction.

The voltage induced in the secondary of a transformer is known as the emf of _____(7)_____ induction.

If nearly all the flux produced by

the primary cuts the conductors of the secondary, thetwo windings are said to be _____(8)_____ coupled.

The primary and secondary windings of a transformer can be identified by the fact that the primary is connected to the _____(9)_____ and the secondary is connected to the _____(10)_____.

When the high tension winding is the primary, the transformer is called a _____(11)_____ transformer.

When the low tension winding is the primary, the transformer is called a _____(12)_____ transformer.

The ratio of primary voltage to secondary voltage is called the ratio of _____(13)_____.

If the effects of resistance are neglected, the primary induced voltage _____(14)_____ the primary applied voltage.

The ratio of primary turns to secondary turns is called the _____(15)Turn _ratio.

The magnetic flux in the core of a transformer is essentially _____(16)_____.

SECTION C

1. The primary winding of a 440/55V transformer has 400 turns. How many turns arethere on the secondary winding?     (50 turns)

2. 240V is applied to the primary winding of a transformer having 1100 turns. If thesecondary has 900 turns, calculate the secondary voltage. (196.3V)

3. A transformer has a turns ratio of 1000:50. Determine the secondary voltage if 240Vis applied to the primary.       (12V)

4. A 240/32V transformer has a primary current of 0.4A. Calculate the current in thesecondary winding.       (3A)

5. A single phase transformer steps down from 415V to 32V. Calculate the primarycurrent if the secondary current is 2A.       (0.154A)

6. A single phase 240/32V transformer has 300 primary turns and takes a primarycurrent of 1A. Determine the -

   a) secondary turns  (40 turns)

b) secondary current  (7.5A)

7. A transformer is wound with 220 turns on the primary and 40 turns on the secondary. The maximum core flux is 0.045Wb and the supply frequency 50Hz. Determine the -

   a) primary voltage   (2198V)

   b) secondary voltage  (399.6V)

   c) transformation ratio  (5.5:1)

8. A transformer with a core flux of 25mWb has a primary winding of 1000 turns and asecondary of 1500 turns. Calculate the secondary voltage if the supply frequency is 50Hz.    (8325V)

9. The maximum flux of a 50Hz transformer is 0.001Wb. If the primary is wound with1080 turns, find the applied primary voltage and then calculate the number of turns required for a 15V secondary.       (239.8V, 67.6 turns)

10. A single phase transformer is wound with 80 secondary turns and the primary voltageis 240V. The core flux is 2mWb at a frequency of 50Hz. Determine the -

    a) secondary voltage  (35.5V)

    b) primary turns   (540.5 turns)

    c) transformation ratio  (6.75:1)

11. A 300/32V, 50Hz single phase transformer has 600 primary turns. Determine themaximum value of core flux.       (2.25mWb)


*SECTION D*

1. Redraw the transformer shown in figure 1 then identify the various parts.
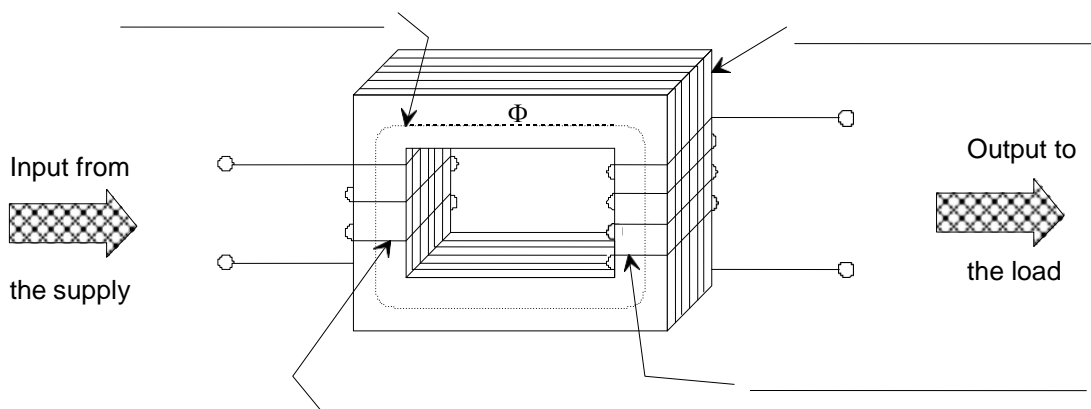
# THE PRACTICAL TRANSFORMER

In the following statements one of the suggested answers is best. Place the identifying letter on your answer sheet.

1. Practical transformer and ideal transformers differ, in that the practical transformerhas -

   a) a perfect transformation ratio
   b) losses
   c) zero hysteresis loss
   d) a better iron loss

2. The core of a transformer is laminated to -

   a) reduce hysteresis loss
   b) reduce eddy current loss
   c) enhance the coupling between windings
   d) make core construction simpler

3. In a transformer, sections of both primary and secondary windings are usually woundon each limb to reduce -

   a) magnetic leakage
   b) iron losses
   c) hysteresis losses
   d) the amount of wire

4. Silicon steel is used for the laminations in a transformer core because it -

   a) has a high resistance
   b) reduces noise
   c) has a high permeability
   d) has a low resistance

5. Silicon steel is used for transformer cores because it -

   a) reduces hysteresis loss
   b) keeps the iron loss to a minimum
   c) is cheaper than ordinary steel
   d) has low resistance

6.  The component of no-load current which lags the transformer primary voltage by 90º is the -

    a) magnetising current
    b) iron loss current
    c) secondary current
    d) primary current

7.  The material most commonly used for transformer windings is -

    a) aluminium
    b) copper
    c) silicon steel
    d) iron

8.  Transformer laminations are prevented from shorting together by -

    a) a varnish or oxide layer on each lamination
    b) a layer of insulation between each lamination
    c) filling the transformer with insulating oil
    d) using spacing blocks to provide air gaps

9.  The approximate phase angle of a transformer operating on no-load is -

    a) 0º
    b) 15º
    c) 85º
    d) 180º

10. The no-load current of a transformer is equal to the -

    a) magnetising current only
    b) iron loss current only
    c) phasor difference of the magnetising and iron loss currents
    d) phasor sum of the magnetising and iron loss current

Blank spaces in the following statements represent omissions. Write the appropriate information on your answer sheet.

1. In practice the____(1)_____load current of a transformer is constant.

   No

2. If the two windings of a transformer are wound, one on top of the other, thewinding is known a____(2)_____type winding.

   Concentric

3. A single phase transformer which has its windings on the centre limb of thelaminations is called a__(3)____type transformer.

   Shell

4. Eddy currents in a transformer are caused by_(4)____in the iron core.
   Iron losses

5. In an unloaded transformer, the magnetising current_(5)____the primaryvoltage by approximately____(6)_____degrees.

   Lags 90

6. Joints in the laminations of a transformer core are staggered so as to minimise _____(7)_____.
   vibration

7. The iron core of a core type transformer is constructed using laminations cut to aparticular shape, and are called___(8)_____and____(9) laminations.

   E / Stacked

8. In smaller transformers the lamination joints may be butted together, whereas in largepower transformers the joints are____(10)__.
   Externally cross tied.

9. Laminations used in the construction of a transformer core are approximately _____(11)_____thick.
   0.25 mm to 0.5 mm

10. If a transformer was constructed using a solid iron core the_(12)____loss would be very large and the transformer would run very hot.

    Iron

11. Flux established by the primary that does not cut the conductors of the secondary isknown as__(13)___flux.
    Leakage

12. The secondary voltage of a transformer is__(14)_____degrees out of phase withthe primary voltage.
    180

13. The only factor that is common to both the primary and secondary

windings of a transformer is the core (15)_____.

<mark>Flux</mark>

14. If a transformer was constructed using a mild steel core the (16)_____ loss would be very large and the transformer would run very hot.

<mark>Iron</mark>

*SECTION C*
<mark>See Teacher's solution</mark>

1. What is meant by the term *leakage flux*, and how is it kept to a minimum?

2. A 240/115V single phase transformer has 960 turns on its primary winding. Calculate the number of turns required on the secondary winding.  (460 turns)

3. A 240/12V downlight transformer draws a no-load current of 0.6A at a phase angle of 80° lag. Using a scale of 1mm = 10mA, draw the no-load phasor diagram for the transformer and from the diagram determine the -

   a) magnetising current  (0.59A)

   b) iron loss current.  (0.104A)

4. 4.A single phase 240/415V transformer has a no-load primary current of 0.8A and takes 78W from the supply. Determine the -

   a) no-load power factor  (0.406 lag)

   b) no-load phase angle (66° lag)

   c) magnetising current  (0.73A)

   d) iron loss current.  (0.325A)

   For parts (c) and (d) use a scale: 1mm = 0.01A

5. A single phase transformer steps down from 415V to 32V. Calculate the primary current if the secondary current is 5A.  (0.386A)

6. A transformer is wound with 250 turns on the primary and 50 turns on the secondary. The maximum core flux is 0.04Wb and the supply frequency 50Hz. Determine the -

   a) primary voltage   (2220V)

   b) secondary voltage  (444V)

c) transformation ratio   (5:1)

7.  A 250/500V transformer has a magnetising current of 4.92A and an iron loss currentof 0.88A. Determine the no-load primary current and phase angle.
    (5A, 79.8⁰ lag)

    Scale: $1\text{mm} = 0.1\text{A}$

8.  A 300/32V, 50Hz single phase transformer has 500 primary turns. Determine themaximum value of core flux.        (0.0027Wb)

*SECTION D*

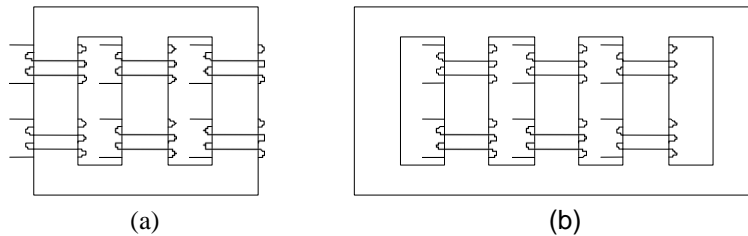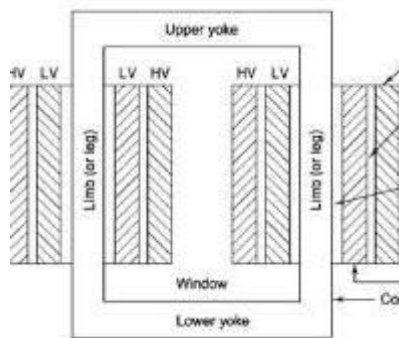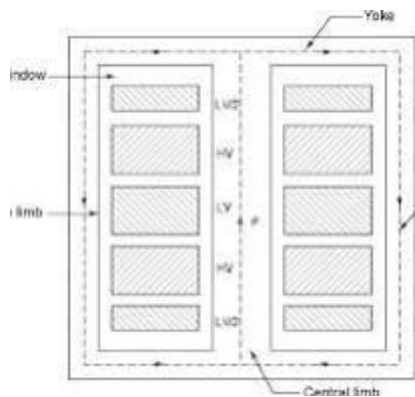1.  Identify the two types of transformer core shown in figure 1.



(a)                                  (b)

Figure 1

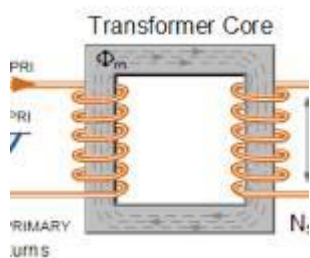==Core==                    ==Shell==

2.  Sketch the winding arrangements for concentric, sandwich and side by side windings.



Concentric



Sandwich



Side by side

3.  Explain why a stepped core would be used in a large power transformer.

Stepped cores in transformer are used to reduce iron in core , copper in winding , better utilization of magnetic field and reduction of iron and copper losses . Eddy current losses in iron core are proportionate to thickness of core or a conductor

4.  List applications for core and shell type transformers.

The core type transformers are mainly used in high voltage applications such as distribution and power transformers

Shell type transformers are often used where a limited amount of space is available. Typical applications include the railway industry, where it is beneficial to lay the transformers on top or underneath the carriages without increasing the overall height of the carriage considerably.

5. Why are transformer laminations clamped tightly together?

To reduce vibration , to improve maghetisation

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# Tutorial 3        **NAME:**

# TRANSFORMER OPERATION

*SECTION A*

In the following statements one of the suggested answers is best. Place the identifying letter on your answer sheet.

1. The primary and secondary voltages of a transformer are -

   a) in phase
   b) $90^0$ out of phase
   c) $120^0$ out of phase
   d) $180^0$ out of phase

2. In a transformer the component of no-load current which lags the primary voltage by $90^0$ is the -

   a) magnetising current
   b) iron loss current

c) secondary current

d) primary current

3. In general the power factor of the primary side of a transformer with an inductivesecondary load is -

a) lower than

b) equal to

c) higher than

d) unrelated to the power factor of the secondary winding.

4. The primary and secondary currents of a transformer are "**approximately**" -

a) in phase

b) 60⁰ out of phase

c) 90⁰ out of phase

d) 180⁰ out of phase

5. The no-load power factor of a transformer is approximately -a) 0.1

b) 1.0

c) 0.9

d) 0.707

6.  Transformers are rated in terms of the -

a) true power out
b) true power in
c) apparent power out
d) apparent power in

7.  In order to obtain maximum cooling effect a transformer tank should be -

a) plain
b) finned
c) tubed
d) painted in a light colour

8.  An oil filled transformer which is cooled by means of a fan blowing across theradiators on the tank is termed -

a) ONAN
b) OFAF
c) OFAN
d) ONAF

9.  Transformer oil is used to -

a) aid cooling of the transformer
b) enhance the level of insulation
c) keep the windings free of moisture
d) aid cooling and enhance the level of insulation

10. As the load on the secondary of a transformer increases -

a) secondary current increases and primary current decreases
b) secondary current decreases and primary current decreases
c) secondary current increases and primary current increases
d) secondary current decreases and primary current increases

## SECTION B

Blank spaces in the following statements represent omissions. Write the appropriate information on your answer sheet.

The power factor of the primary of a lightly loaded transformer is generally _____(1)_____ than the power factor of the secondary load because of the effect of the _____(2)_____ current.

Lower , magnetizing

Transformers are usually rated in _____(3)_____.

KVA

The main function of oil in a transformer is to _____(4)_____ the transformer.

Cool

The cooling mediums used in transformers are designated with the letters A, O and W. The letter A stands for _____(5)_____, the letter O _____(6)_____ and the letter W _____(7)_____.

Air, Oil , Water

Cooling methods used in conjunction with transformers are designated by the letters N and F. The letter N stands for _____(8)_____ and the letter F _____(9)_____.

Natural, Forced

The rating of a transformer is determined by its ability to dissipate heat under _____(10)_____ load conditions.

Full

The primary current of a transformer is made up of two main components, the no-load current and the _____(11)_____ component of primary current.

Secondary reflected

A transformer that is cooled using only the surrounding air and oil in and around the windings, would be classified as _____(12)_____.

AN

The load component of primary current is determined using the secondary current and the _____(13)_____ ratio or the _____(14)_____ ratio.

Turn, Voltage

The primary current of a transformer is equal to the _____(15)_____ sum of the no-load current and the load component of primary current.

Phasor

If a 100kVA transformer is required to deliver 110kVA for an extended period, it is most likely that the transformer windings would _____(16)_____.

Overheat

*SECTION C*
See Teacher's Solution

1. Question 14.15, page 355, Electrical Principles for the Electrical Trades.($N_1$ = 1833.3 turns, $N_2$ = 41.67 turns, $I_1$ = 5.25A, $I_2$ = 230.94A)

2. A single phase 240/32V transformer is to supply a low voltage lighting circuit. The no-load current of the transformer is 2A at a power factor of 0.1 lag. If the lights takes a current of 40A at unity power factor, determine the -

   a) primary current          (5.9A)
   b) primary phase angle     ($20^0$ lag)
   c) primary power factor.   (0.94

lag)Scale: 1mm = 0.1A

3.  A 33/11kV, 20MVA transformer is used in a zone substation. Neglecting any lossesdetermine the -

    a)  full load secondary line current  (1049.7A)

    b)  full load primary line current    (349.9A)

4.  A 240/12V downlight transformer has a rating of 100VA. Determine the -

    a)  full load secondary current (8.33A)

    b)  number of 50W lamps that may be supplied from the transformer.　　(2)

5.  A 240/110V single phase transformer takes a no-load current of 2.5A at a power factor of 0.1 lag. If the transformer supplies a load current of 20A at a power factorof 0.866 lag, determine the -

    a)  load component of primary current(9.17A)

    b)  primary current   (10.82A)

    c)  primary phase angle (41⁰)　　　　　Phasor diagram scale; 1mm = 0.1A

    d)  primary power factor  (0.75 lag)

*SECTION D*

1.  What methods of cooling are used on the transformer shown in figure 1?
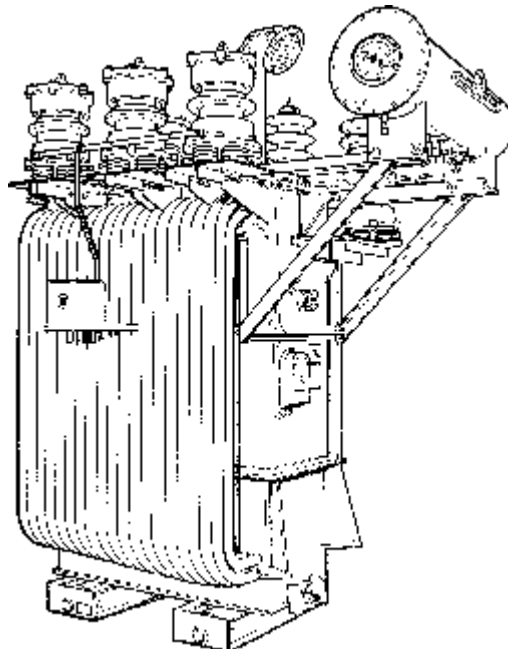
Figure 1

2. Is the transformer shown in figure 1, a single or three phase transformer?

# Transformer Impedance,
# Regulation and Efficiency

*SECTION A*

In the following statements one of the suggested answers is best. Place the identifying letter on your answer sheet.

1.  The efficiency of a transformer -

    a) is constant over the load range
    b) has a maximum of 90%
    c) varies with load
    d) varies with the iron losses

2.  The impedance of a transformer -

    a) causes secondary voltage to drop when load current increases
    b) limits fault current when secondary is short circuited
    c) is determined by the core material and winding resistance
    d) all of the above

3.  The iron loss of a transformer at rated voltage and frequency is -

    a) proportional to the load current
    b) proportional to the square of the load current
    c) practically constant at all times
    d) dependent on the power factor of the load

4.  The voltage drop within a transformer can be allowed for by-

    a) using a tap changer to boost the secondary voltage
    b) increasing the primary voltage
    c) reducing the coupling between windings
    d) increasing the turns on the primary

5.  The iron loss of a transformer can be determined by measuring the power taken bythe transformer when -

    a) the secondary is short circuited
    b) normal load is applied to the secondary circuit
    c) the secondary is open circuit and half normal voltage is applied to the primarywinding
    d) the secondary is open circuit and normal voltage is applied to the primary winding

6. If the load on a transformer is doubled the iron losses are -

   a) doubled
   b) halved
   c) constant
   d) decrease slightly

7. The short circuit test on a transformer is used to determine -

   a) ohmic impedance
   b) percentage impedance
   c) copper losses
   d) all of the above

8. A single phase transformer is rated at 20kVA at 100V. The true power output atfull-load and 0.8 power factor is -

   a) 25kW
   b) 20kW
   c) 16kW
   d) 8kW

9. The all day efficiency of a transformer is the ratio of the -

   a) input energy over 24 hours to the output energy over 24 hours
   b) output kVA over 24 hours to the input kVA over 24 hours
   c) input kVA over 24 hours to the output kVA over 24 hours
   d) output energy over 24 hours to the input energy over 24 hours

10. If a transformer operates for long periods during a day with no-load, the all dayefficiency of the transformer is -

    a) high
    b) very low
    c) not affected by no-load operation
    d) reduced slightly

*SECTION B*

Blank spaces in the following statements represent omissions. Write the appropriate information on your answer sheet.

Transformers are rated in_____(1)_____because this allows the power factor of the load to be ignored. KVA

Maximum efficiency of a transformer occurs at the load which makes the _____(2)_____equal to the_____(3)_____. Iron/ Copper

The short circuit test on a transformer is used to deter

mine the_____(4)_____losses.

Copper

The copper losses of a transformer are 400W at full-load. If the load is reduced to half load, the copper losses are_____(5)_____watts.

100

Copper losses in a transformer vary as the_____(6)_____of the current.

square

The_____(7)_____losses in a transformer are constant for all loads at rated voltage and frequency.

iron

When measuring the iron losses of a transformer, the secondary winding must be_____(8)_____.

open

The efficiency of a transformer is the ratio of the_____(9)_____power to the_____(10)_____power.

Output / input

Subtracting the output power from the input power gives the_____(11)_____of a transformer.

Losses

To achieve the best all day efficiency, a transformer should be operated at or near_____(12)_____load for the entire day.

75%

Voltage regulation of a transformer is voltage drop between no load and full load expressed as a_____(13)_____of no load volts.

percentage

Typical values of transformer efficiency fall within the range_____(14)_____to_____(15)_____.

The efficiencies of power transformers normally vary from 97 to 99 percent. The power supplied to the load plus resistive, eddy current, hysteresis, and flux losses must equal the input power. The input power is always greater than the output power.[16]

The voltage required to cause rated current to flow during a short circuit test expressed as a percentage of rated voltage is known as_____(16)_____.

*impedance voltage*

*SECTION C*
See Teacher's solution

1. Calculate the efficiency of a 500kVA distribution transformer when operating atfull-load with a power factor of 0.9 lag. The total losses are 15kW.                                              (96.8%)

2. A transformer when tested using the open circuit test had an iron loss of 3700W andwhen tested using the short circuit test had a copper loss of 2100W. Determine the total transformer loss.          (5800W)

3. A 10MVA transformer operates with a power factor of 0.85. The transformer ironlosses are 120kW and the copper losses 95kW. Calculate

the efficiency of the transformer.     (97.5%)

4. A 33kV/11kV, three phase transformer with a rating of 500kVA has a voltage regulation of 6% at a power factor of 0.8. Determine the secondary line and phase voltage of the transformer at full load 0.8 power factor if the no load line voltage is11kV. ($V_L$=10340V, $V_P$= 5970V)

5. A 33kV/11kV, three phase transformer with a rating of 500kVA has a percentage impedance of 4.5%. Determine the secondary prospective short circuit current of thetransformer. (583A)

6. Determine the full load efficiency of a transformer supplying full load output of 15kW at unity power factor, if the transformer has iron losses of 400W and copperlosses of 800W when tested at full load.　(92.6%)

7. A 50kVA transformer has a full load copper loss of 460W and an iron loss of220W. Determine the -

   a) iron loss when delivering 25kVA　(220W)

   b) copper loss when delivering 25kVA. (115W)

8. Calculate the all day efficiency for a 750kVA, 11kV/415V distribution transformerthat operates with the following energy levels and times -
   8 hours delivering 800kW with an input of 810kW
   2 hours on no-load, taking 20kW
   6 hours delivering 350kW with an input of 370kW
   8 hours delivering 600kW with an input of 615kW.　(97.36%)

*SECTION D*

1. Re-draw the components in figure 1 to show the connections required to carry outa short circuit test on the transformer.
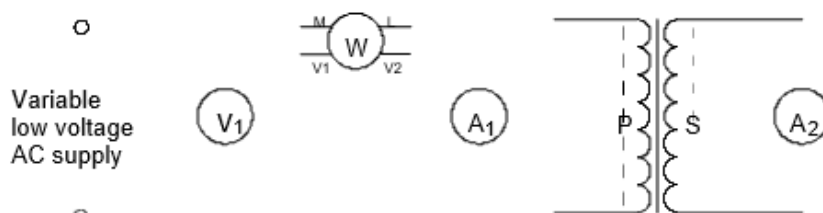
Figure 1

2. Re-draw the components in figure 2 to show the connections required to carry out an open circuit test on the transformer.
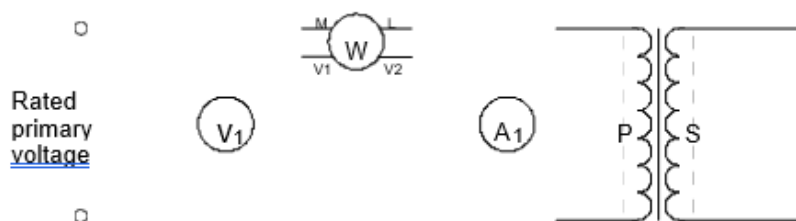


Figure 2

2. Draw a set of axis showing percentage efficiency versus load for a transformer. Onyour axis show the characteristics for efficiency, copper loss and iron loss. Also show the condition required for maximum efficiency.

# TRANSFORMER POLARITY & PARALLELING

*SECTION A*

In the following statements one of the suggested answers is best. Place the identifying letter on your answer sheet.

1. Transformers are paralleled when -

   a) a greater output voltage is required
   b) <mark>the load becomes too large for one transformer</mark>
   c) transformer regulation must be minimised
   d) the effect of the vector groups must be reduced

2. A transformer designated Dy11 would have a -

   a) star primary, delta secondary and $0^0$ phase shift
   b) star primary, delta secondary and $30^0$ phase shift
   c) <mark>delta primary, star secondary and $30^0$ phase shift</mark>
   d) delta primary, delta secondary and $0^0$ phase shift

3. Load sharing by parallel transformers of equal rating is dependent upon therespective transformer -

   a) line voltage
   b) vector group
   c) impedance
   d) <mark>voltage regulation</mark>

4. When conducting a final additive/subtractive polarity test for paralleling two singlephase transformers, the voltmeter is connected across -

   a) each transformer primary winding
   b) each transformer secondary winding
   c) <mark>the two transformer secondaries in series</mark>
   d) the two transformer primaries in parallel

5. Which of the following combinations of three phase transformers may be paralleled

   a) star/star and star/delta
   b) delta/star and star/star
   c) delta/delta and star/delta
   d) <mark>delta/star and star/delta</mark>

6. Which of the following combinations of three phase transformers may be paralleled

   a) star/star and star/delta
   b) delta/star and star/star
   c) delta/delta and star/delta

**Detailed Solution**

**Concept:** Conditions to be satisfied for parallel operation of transformers:

1. Voltage ratings must be same.

2. Must be connected with correct polarity.

3. The phase sequence must be same.

4. Apart from phase sequence matching, the phase displacement between the seconderies of both transformers must be zero. This condition can be fulfilled if the two transformers belong to same phasor group.

| Phasor displacement | Transformer connections |
|---|---|
| Phasor group 1 | 0° Δ/Δ, Y/Y, Δ/Zig Zag Y |
| | 180° Δ/Δ, Y/Y, Δ/Zig Zag Y |
| Phasor group 2 | ±30° Δ/Y, Y/Δ, Y/Zig Zag Y |
| | ±150° Δ/Y, Y/Δ, Y/Zig Zag Y |

---

7. As long as certain other characteristics are identical, a 3-phase star/delta transformercan be connected in parallel with a second transformer which has its primary delta connected and its secondary connected in -

   a) delta
   b) star
   c) inter-star
   d) zig-zag

8. Three phase transformers that are to be paralleled -

   a) must come from an alternate vector group
   b) can come from any vector group
   c) are not affected by their vector group
   d) must come from the same vector group

9. Transformer polarity marks indicate the direction of current -

   a) into the primary and out of the secondary
   b) out of the primary and into the secondary
   c) into the primary and into the secondary
   d) out of the primary and out of the
         secondaryat the same instant

10. When the primary and secondary terminal voltages are in the same direction atevery instant, the transformer is said to have -

    a) additive polarity
    b) negative polarity
    c) subtractive polarity
    d) positive polarity

11. Which of the following combinations of three phase transformers may be paralleled

    a) Dy1 and Dy11

b) Dy11 and Yd1
c) Yy0 and Dd6
d) Dy1 and Yd1

SECTION B

Blank spaces in the following statements represent omissions. Write the appropriate information on your answer sheet.

When two transformers of equal rating are paralleled, the transformer with the _____(1)_____impedance will take the greater share of load.
lower

If two transformers of equal rating and impedance are paralleled, the transformers will share the load_____(2)_____.

equally

Transformers are connected in parallel to provide additional_____(3)_____.
load

Transformers are paralleled when the load becomes_____(4)_____for one transformer.

Greater

Identical single phase transformers that are to be paralleled must have the same _____(5)_____,_____(6)_____and_____(7)_____.
Voltage, Phase sequence, Polarity

The two methods used to mark the polarity of the terminals of a transformer are _____(8)_____and_____(9)_____.
X1   X2
when facing the low-voltage side of a single-phase transformer (the side marked X1, X2), the H1 connection will always be on your far left. If the terminal marked X1 is also on your left, it indicates subtractive polarity.

When the primary and secondary terminal voltages of a transformer are in the same direction at every instant, the transformer is said to have_____(10)_____polarity.

addative

When the primary and secondary terminal voltages of a transformer are in opposite directions at every instant, the transformer is said to have____(11)____polarity.

Three phase transformers that are to be paralleled must have identical____(12)____, ____(13)____,____(14)____,____(15)____and____(16)____.

<mark>substractive</mark>

*SECTION C*
<mark>See Teacher's solution</mark>

1.  Three single phase 5:1 transformers have their primaries connected in star to a 415V supply. The delta connected secondaries supply three 6Ω star connectedelements. Determine -

    a)  primary phase voltage (240V)
    b)  secondary phase and line voltages   (48V, 48V)
    c)  load phase current (4.62A)
    d)  secondary line current (4.62A)
    e)  secondary phase current       (2.67A)
    f)  primary phase and line current.       (0.53A, 0.53A)

2.  A three phase 415V inductive load is to be supplied by a three phase delta/star stepdown transformer. If the primary line voltage is 1000V, determine the required transformer ratio.       (4.17:1)

3.  A three phase 11kV/415V star-star transformer supplies a load consisting of threedelta connected heating elements. If the secondary line current is 173A determinethe -

    a)  transformation ratio  (26.46:1)
    b)  load phase current (100A)
    c)  load phase voltage (415V)
    d)  resistance of each heating element   (4.15Ω)
    e)  transformer primary line current. (6.54A)

4.  Two transformers of equal rating are to be paralleled to supply a load of 3MVA. If transformer A has an impedance of 5% and transformer B an impedance of 4.5%, determine how the transformers will share the load. (Tx A = 1.42MVA and Tx B
    = 1.58MVA)

5.  Two 33kV/5kV, 15MVA transformers are to be paralleled. Show by calculation ifthey will operate satisfactorily to supply a 25MVA load. The transformer impedances are %$Z_A$ = 6% and %$Z_B$ = 3.5%. (Tx A = 9.2MVA and Tx B = 15.8MVA, not satisfactory Tx B overloaded)

*SECTION D*

1.  What would be the expected voltmeter readings in the circuit of figure 1, if thetransformers were -

    a) correctly paralleled
    b) incorrectly paralleled.
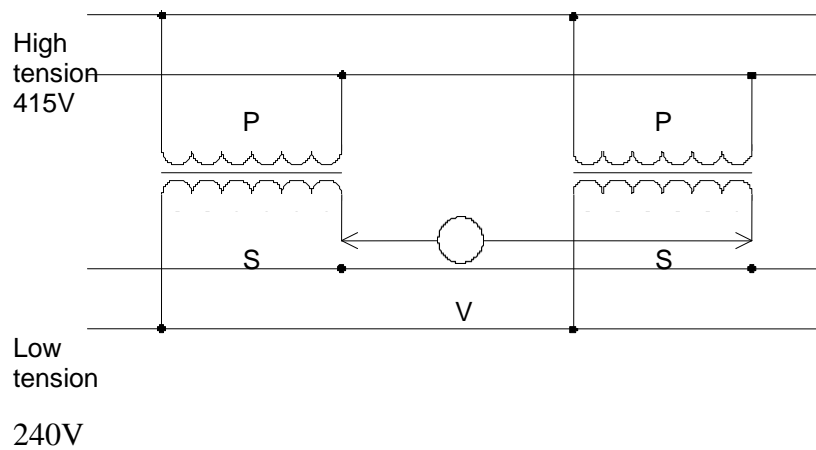


Figure 1

2. What would be the expected voltmeter readings in the circuit of figure 2, if the transformers were -

   a) correctly paralleled
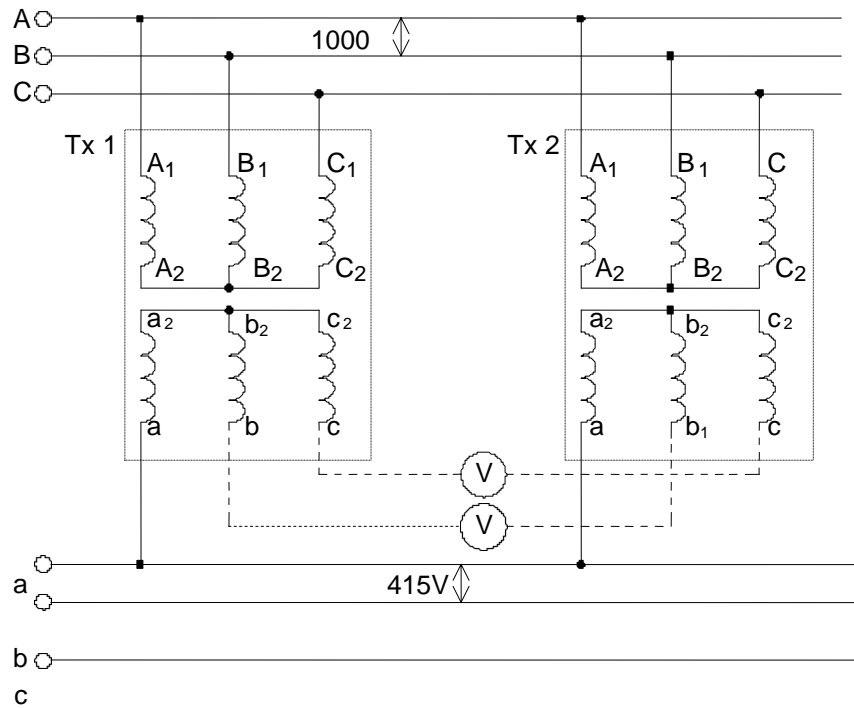   b) incorrectly paralleled.

Figure 2

# INSTRUMENT & AUTO-TRANSFORMERS

*SECTION A*

In the following statements one of the suggested answers is best. Place the identifying letter on your answer sheet.

1. In an auto transformer the current in the primary is 10 amperes and the current inthe secondary is 20 amperes; the current in the common part of the winding is—

   a) 30 amperes.
   b) 20 amperes.
   c) 15 amperes.
   d) 10 amperes.

2. The current in the common section of the winding of an auto transformer, when onload is equal to—

   a) the phasor sum
   b) the phasor difference
   c) the sum.
   d) the difference

      of the primary and secondary currents.

3. When an auto transformer is properly designed, one of the features compared to adouble wound transformer of the same rating is -

   a) larger physical size
   b) requires less material to manufacture
   c) has a lower efficiency
   d) has higher losses

4. The rated secondary current of a standard current transformer is -

   a) 0.6A
   b) 5A
   c) 10A
   d) 25A

5. The rated standard secondary voltage of a potential transformer is -

   a) 415V
   b) 240V
   c) 120V
   d) 110V

6. If the instrument is to be removed from the secondary of a current transformer it isnecessary to -

   a) short circuit the primary terminals
   b) short circuit the secondary terminals
   c) open circuit the secondary terminals
   d) open circuit the primary terminals

7. A certain current transformer when operating at full rated current has a primarycurrent of 550A, the secondary current would be -

   a) 110A
   b) 10A
   c) 5A
   d) unknown

8. An 11kV potential transformer has a primary voltage of 11kV applied, thesecondary voltage would be -

   a) 110V
   b) 5V
   c) 1V
   d) unknown

*SECTION B*

Blank spaces in the following statements represent omissions. Write the appropriate information on your answer sheet.

Instrument transformers are usually rated in terms of their___(1)___output.

burden

The secondary of a___(2)___transformer must always be short circuited before disconnecting its associated meter.

Current

The more common Australian standard secondary current of a current transformer is ___(3)___amperes.

5

The primary circuit of instrument type___(4)___transformers should always be protected by fuses.

Potential

When the primary of a current transformer is energised and the secondary is open circuited, a high___(5)___is produced at the secondary terminals.

Voltage

Auto transformers are transformers with a___(6)___winding.

single

The current in the common part of an auto transformer is the___(7)___of the primary and secondary currents. Difference

In an auto transformer, the primary current is 5A and the secondary current is 12A. The current in that part of the winding which is common to the primary and secondary is _____(8)_____amperes.

7A

The applications of auto transformers is limited due to the danger of a_____(9)_____ between the primary and secondary.

Short circuit

The minimum acceptable insulation resistance for a transformer between windings is _____(10)_____and between windings and earth_____(11)_____.

1 Mega Ohm  1 Mega Ohm

To provide additional protection, some transformers are fitted with an_____(12)_____ shield between the primary and secondary windings.

Special insulation

Instrument transformers are of two types,_____(13)_____transformers and _____(14)_____transformers.

Current/ Potential

A variac is an example of the use of an_____(15)_____transformer.

Auto

The rated standard secondary voltage of a potential transformer is_____(16)_____ volts.

120V

*SECTION C*

See Teacher's solution

1. An auto transformer is used to step down from 300 volts to 200 volts. The complete winding consists of 600 turns and the secondary current is 30 amperes. Determine:

   a) secondary turns  (400 turns)
   b) primary current   (20A)
   c) current in common portion of winding, neglect all losses      (10A).

2. Determine the current at full load, in the common section of the winding of a singlephase 440/415V, 5kVA auto transformer. Neglect losses. (0.69A)

3. A 400/32V, 0.5kVA, single phase auto transformer delivers full load at unity power factor. Determine the current in the common section of the winding. Neglect losses.(14.375A)

4. An auto transformer is used to step up from 200 volts to 250 volts. The primary winding consists of 400 turns and the secondary current is 20 amperes. Determine:

   a) secondary turns  (500 turns)
   b) primary current   (25A)
   c) current in common portion of winding, neglecting all losses   (5A).

5. A 500/5A CT has a primary current of 450A, what is the secondary current?(4.5A)

6. A 415/110V potential transformer has a primary applied voltage of 425V, what is the secondary voltage?　　　(112.65V)

7. A 1000/5A CT has a secondary current of 3.5A, what is the primary current? (700A)

8.  A three phase, 11kV/415V, delta/star transformer supplies a star connected loadconsisting of three 15Ω heating elements. Determine -

    a)  primary phase voltage (11kV)
    b)  secondary phase and line voltages   (240V, 415V)
    c)  load phase voltage (240V)
    d)  load phase current (16A)
    e)  secondary line current (16A)
    f)  secondary phase current       (16A)
    g)  transformation ratio  (45.83:1)
    h)  primary phase and line current.       (0.349A, 0.605A)

9.  A three phase 11kV/415V star-star transformer supplies a load consisting of threedelta connected heating elements. If the secondary line current is 200A determinethe -

    a)  transformation ratio  (26.46:1)
    b)  load phase current (115.47A)
    c)  load phase voltage (415V)
    d)  resistance of each heating element  (3.59Ω)
    e)  transformer primary line current. (7.56A)

10. Two transformers of equal rating are to be paralleled to supply a load of 2MVA. Iftransformer A has an impedance of 5% and transformer B an impedance of 4%, determine how the transformers will share the load. (Tx A = 0.889MVA and TxB = 1.111MVA)

*SECTION D*

1.  Re-draw the symbols shown in figure 1 and connect the ammeter, voltmeter and wattmeter to measure the line current and line voltage of the three phase motor. The instruments are to be connected via instrument transformers. Note, a bar type CT is used.
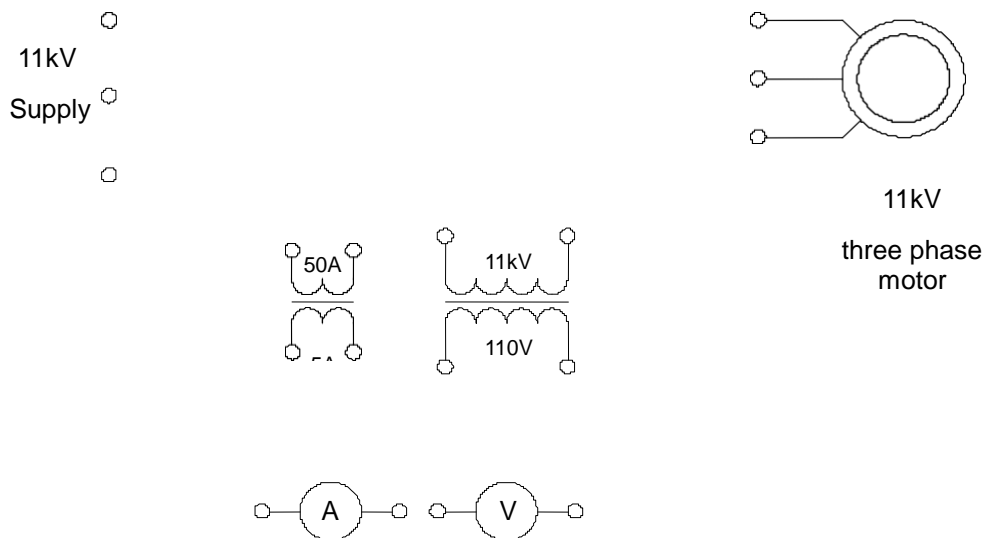


Figure 1

11kV

Supply

50A

11kV

110V

A

V

11kV

three phase
motor