Electric Machine – 1

Assignment – 4

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1/ Explain Sumpher Back to Back test on Single phase transformer. What are the necessary Condition for this test?

The Sumpher's Back to Back test, also Known Regenerative test, is used for finding efficiency and regulation of a Transformer under full-load Conditions, without actually loading it.

It is done on two identical Single-phase transformers.

* Purpose of the Sumpher's test, →

1/ To measure the efficiency of a transformer at

2/ To measure full load losses (Iron + Copper) loss.

3/ To Simulate full-load Condition (including temperature rise) without Connecting an Actual load.

3/ To reduce power Consumption during testing - power drawn is only enough to supply the losses.

* Test Set'up, -

Take Two Identical Single-phase transformer are required.

- Primaries of both transformer are Connected in parallel and Supplied from the rated Voltage source.
- Secondaries are Connected in opposition (Series adding) so their Voltages oppose each other.

- An auxiliary Voltage Source (low Voltage) is connected in the Secondary loop to Circulate full-load Current through both transformers

- Working principle →
  - The Supply to primaries provide the Core (iron) losses, Since rated Voltage is applied.
  - The auxiliary Voltage in the Secondary Causes Circulating full load Current, which leads to Copper losses in the windings.
  - No actual Output load is connected - yet both transformers experience full-load Conditions.

Necessary Condition for Sumpner's Test, →

1) Two identical Transformers :→
   - Same rating (KVA), Voltage ratio, impedance.
   - Ensures balanced loading and Symmetrical operation.

2) Rated Voltages as Primaries :→
   - Applied from the main supply to determine loss iron Correctly.

3) Secondary Connected in opposing polarity.
   - When connected, they should ideally Cancel each other out (zero net voltage), so a small external Voltage source Can Circulate rated Current.

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4. Auxiliary Voltage Source :-
   - Needed to Circulate full-load current in secondary loop.
   - Should be adjustable and capable of supplying rated VA secondary current.

5. Proper Instrument :-
   - Wattmeter on both
     - → Primary side : for Core (iron) loss.
     - → Secondary Circulating Circuit : For Copper loss

* Advantage :
   - Full-load test without actual load.
   - Very economical (low power wasted).
   - Accurate efficiency & Regulation.
   - Checks temperature rise under rated load
   - Suitable for large transformers.

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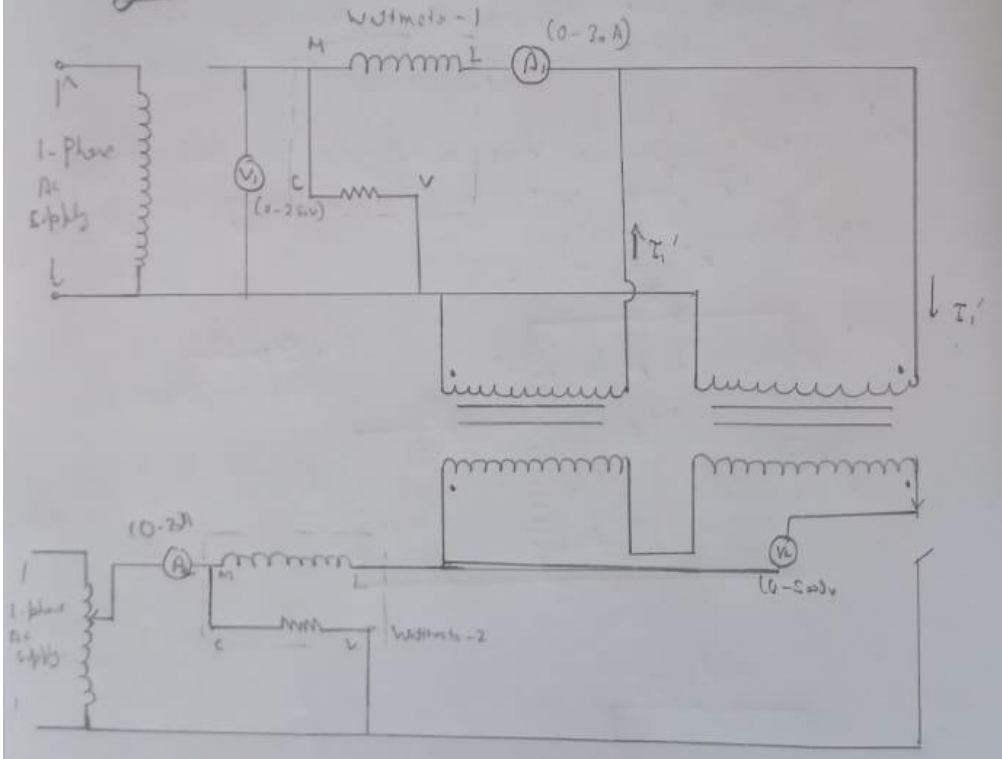
- W_1 (Wattmeter) = Connected in Primary Circuit.
  → measure iron Core loss.
- W_2 (Wattmeter) = Connected in Secondary Circuit.
  → measure Copper losses.

Diagram

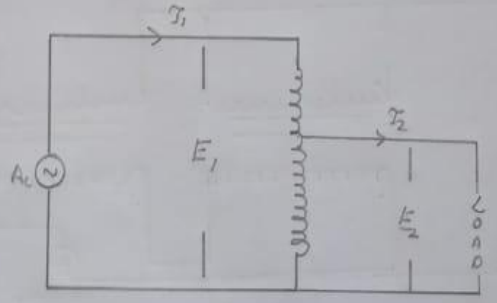


2] What is an Auto Transformer? Derive the equation for Conductive and inductive power transfer in Auto Transformer.

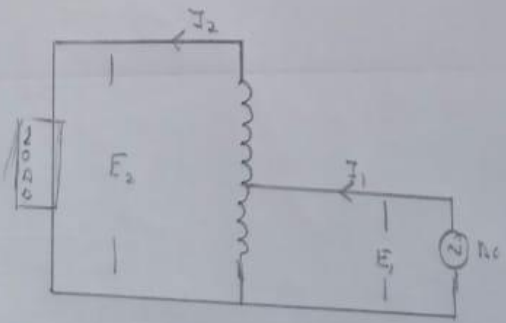
⇒ An auto transformer is a transformer with only one winding on a laminated Core.

An auto transformer is similar to two winding transformer but different in the way the primary and Secondary winding are interrelated.

An autotransformer has a Single Consistent Winding with tap point between the primary winding and Secondary Winding



Step Down Autotransformer



Step up Autotransformer

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For Stepup Auto transformer

- S (Apparent power) $= V_1 I_1 = V_2 I_2$

  Now, $V_1 < V_2$ & $I_1 > I_2$

  At Node B Applying KCL, $I_2 + I = I_1$

  $\boxed{I = I_1 - I_2}$

- BC : Common Winding

  Ac : Series Windig

for inductive power transformer, we have chosen Common windig Bc.

- $S_{ind} = V_1 (I_1 - I_2) = V_1 (I_1 - I_1/k) = V_1 I_1 (1 - 1/k)$

  $\therefore S_{ind} = S(1 - 1/k)$

$\boxed{S_{total} = S_{ind} + S_{cond}}$

- $S = S(1 - 1/k) + S_{cond}$

  $S_{cond} = S - S(1 - 1/k)$

  $\boxed{S_{cond} = S/k}$

• For Step Down Auto transformer.

• In IDEAL Transformer.

→ Power Conservation.

S (Apparent power) $= V_1 I_1 = V_2 I_2$

Now, $V_1 > V_2$ $I_1 < I_2$

BC → Common Winding
AB → Series Winding.

At node B applying KCL

$I + I_1 = I_2$

$I = I_2 - I_1$

for inductive power transform we have choosen Common winding BC.

$S_{inductive} = V_2 (I_1 - I_1)$

$= KV (I_2 - I_1)$

$= V_1 (KI_2 - KI_1)$

$= V_1 (I_2 - KI_1) = VI_1 (1-K)$

$S_{inductive} = S(1-K)$

$S_{Total} = S_{ind} + S_{cond} \Rightarrow S(1-K) + S_{cd}$

$S_{cond} = S - S(1-K)$

$\boxed{S_{cond} = SK}$