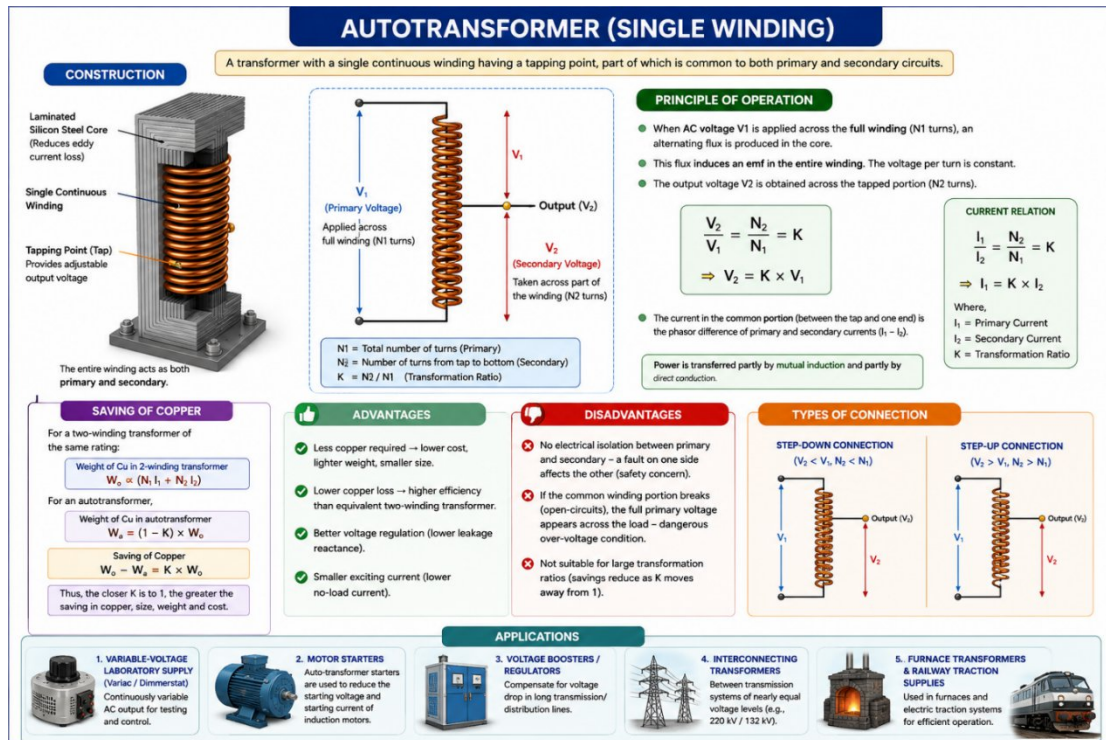


Autotransformer

Construction

An autotransformer is a special type of transformer having only ONE winding, part of which is common to both the primary and secondary circuits. Unlike a two-winding transformer, it transfers power partly by conduction (direct electrical connection) and partly by mutual induction.



The winding is wound on a laminated core just like an ordinary transformer, but only a single continuous winding is used, with a movable or fixed tapping (tap) that divides it into two sections. The input voltage V_1 is applied across the full winding (N_1 turns), and the output V_2 is taken across a part of it (N_2 turns), or vice versa for a step-up connection.

Principle of Operation

When V_1 is applied across the full winding, current flows and produces flux in the core exactly as in a two-winding transformer, inducing a voltage per turn. The output voltage V_2 is simply proportional to the number of turns tapped, $V_2 = (N_2/N_1) V_1$. The portion of the winding common to both circuits carries the (phasor) difference of the primary and secondary currents, which is much smaller than either current — this is the key to the copper saving of an autotransformer.

Saving of Copper

For a two-winding transformer of the same rating, weight of copper required is proportional to $(N_1 I_1 + N_2 I_2)$. For an autotransformer with transformation ratio $K = N_2/N_1 = I_1/I_2$:

Weight of Cu in autotransformer, $W_a = (1 - K) \times \text{Weight of Cu in ordinary transformer, } W_o$

Saving of Copper = $W_o - W_a = K \times W_o$ (i.e., a fraction K of the copper is saved)

Thus, the closer K is to 1 (i.e., primary and secondary voltages are close to each other), the greater the saving in copper, size, weight, and cost. This saving is the biggest advantage of an autotransformer over a two-winding transformer.

Advantages

- Less copper required → lower cost, lighter weight, smaller size for the same rating.
- Lower copper loss → higher efficiency than an equivalent two-winding transformer.
- Better voltage regulation (lower leakage reactance).
- Smaller exciting current (lower no-load current) required.

Disadvantages

- No electrical isolation between primary and secondary — a fault on one side directly affects the other side, which is a safety concern.
- If the common winding portion breaks (open-circuits), the full primary voltage appears across the load — dangerous over-voltage condition.
- Not suitable for large transformation ratios (savings reduce as K moves away from 1).

Applications

- **Variable-voltage laboratory supply (Variac / dimmerstat):** Continuously variable AC output for testing and control.
- **Motor starters:** Auto-transformer starters for reduced-voltage starting of induction motors.
- **Voltage boosters / regulators:** Compensate for voltage drop in long transmission/distribution lines.
- **Interconnecting transformers:** Between transmission systems of nearly equal voltage levels (e.g., 220 kV/132 kV interconnection).
- **Furnace transformers and railway traction supplies.**

Three-Phase Transformer

Necessity

Electric power is generated, transmitted and distributed almost universally as three-phase AC. Three-phase transformation can be achieved either by using a bank of three identical single-phase transformers connected suitably, or by using a single three-phase transformer unit (common core with three sets of windings).

Construction (Brief)

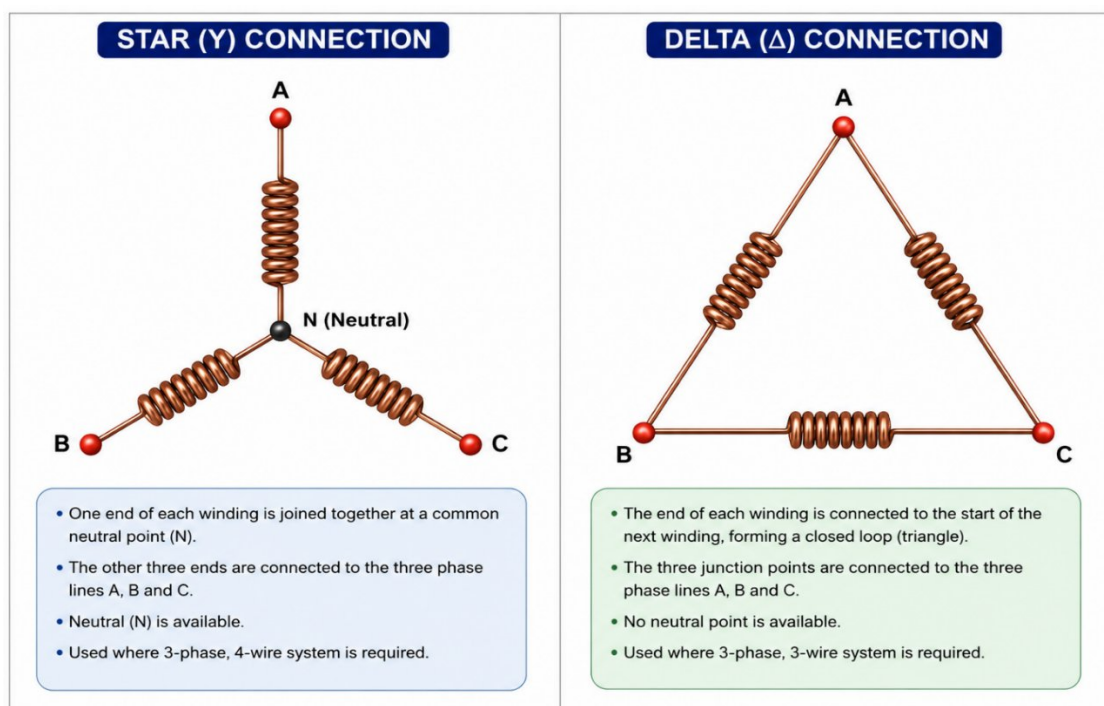
A three-phase transformer core is generally of the core type, with three limbs (one per phase) connected by top and bottom yokes. Each limb carries the LV and HV windings of one phase, similar in principle to a single-phase core-type transformer, but with three limbs instead of two.

Three-Phase Unit vs Bank of Single-Phase Transformers

Feature	Single 3-Phase Unit	Bank of 3 Single-Phase Units
Cost & weight	Lower (shared core & tank)	Higher
Floor space	Less	More
Spare/standby requirement	Entire unit must be spared	Only one single-phase unit needed as spare
Effect of one phase failing	Whole transformer goes out of service	Can run at reduced (open-delta) capacity using remaining two
Transportation (very large ratings)	Difficult (very heavy/bulky)	Easier (smaller individual units)

Three-Phase Transformer Connections

The primary and secondary windings of a three-phase transformer (or bank) can each be connected in Star (Y) or Delta (Δ), giving four common combinations.



Connection	Key Features	Typical Applications
Star – Star (Y–Y)	Provides a neutral on both sides; economical for HV since phase voltage is line/ $\sqrt{3}$; no phase shift; but distorted (non-sinusoidal) flux/voltage due to triplen harmonics unless a tertiary delta winding is added.	Small, low-voltage, high-current transformers where a neutral is required on both sides.
Delta – Delta (Δ – Δ)	No neutral available; no phase shift between primary & secondary; if one transformer of the bank fails, the remaining two can continue supply in open-delta (V–V) at reduced (58%) capacity.	Medium voltage industrial supply; ideal where continuity of supply is critical.
Star – Delta (Y– Δ)	Primary in star (neutral available, good for HV side & grounding); secondary in delta; introduces a 30° phase shift; suppresses triplen harmonics (circulate in delta).	Step-down substations at the receiving end of transmission lines.
Delta – Star (Δ –Y)	Primary in delta, secondary in star (neutral available on LV/output side for 3-phase + neutral distribution); 30° phase shift.	Step-up transformers at generating stations; distribution transformers supplying 3-phase + neutral loads.