Introduction to Transformers
Transformers

Transformer – A device consisting of two or more coils that are used to couple electrical energy from one circuit to another while maintaining electrical isolation between the two.

Primary Winding – First winding of a transformer that is connected to the source.

Secondary Winding – Output winding of a transformer that is connected to the load.
Mutual inductance

Mutual Inductance – The ability of one inductor’s magnetic lines of force to link with another inductor.
Transformer action

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Transformer loading

Unloaded

Loaded

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Coefficient of coupling \((k)\)

The degree of coupling that exists between two circuits.

\[
k = \frac{\text{flux linking secondary coil}}{\text{total flux produced by primary coil}}
\]
Transformer ratios

Turns Ratio – Ratio of the number of turns in the secondary winding to the number of turns in the primary winding of a transformer.

\[
\text{Turn Ratio} = \frac{N_S}{N_P}
\]
Voltage ratio

\[ \frac{V_S}{V_P} = \frac{N_S}{N_P} \]
Step-up transformer

Step-Up Transformer – A transformer in which the ac voltage induced in the secondary is greater (due to more secondary windings) than the ac voltage applied to the primary.
Step-down transformer

Step-Down Transformer – A transformer in which the ac voltage induced in the secondary is less (due to fewer secondary windings) than the ac voltage applied to the primary.
Power and current ratios

\[
\frac{N_s}{N_p} = \frac{I_p}{I_s} = \frac{V_S}{V_P}
\]

\[P_S = P_P\]
Impedance ratio

\[
\frac{N_S}{N_P} = \sqrt{\frac{Z_L}{Z_S}}
\]

\(Z_L = \text{Load Impedance in Ohms}\)

\(Z_S = \text{Source Impedance in Ohms}\)
Maximum power transfer theorem

The maximum power will be absorbed by the load from a source, when the impedance of the load is equal to the impedance of the source.
Impedance matching

![Diagram of impedance matching](image)
Winding and phase

Primary and secondary in phase

Primary and secondary out of phase

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Dot convention

A standard used with transformer symbols to indicate whether the secondary voltage will be in phase or out of phase with the primary voltage.
Transformer types

Fixed turns ratio transformers
Variable turns ratio transformers
Center tapped transformers
Multiple winding transformers
Single winding Transformers (autotransformers)
Transformer ratings

Example: 1 KVA  500/100  60Hz

1 KVA – Apparent power rating
500 – Maximum primary voltage
100 – Maximum secondary voltage
60HZ – Operating frequency
Testing transformers

Open primary or open secondary → No voltage across the load

Partial or complete short in primary winding → Excessive secondary current and a blown fuse

Partial or complete short in secondary winding → Excessive secondary current and a blown fuse
Transformer losses

Copper loss – Also called $I^2R$ loss, it is the power lost in transformers, generators, connecting wires, and other parts of a circuit because of current flow ($I$) through the resistance ($R$) of the conductors.
Transformer core losses

Hysteresis – The amount that the magnetization of a material lags the magnetizing force due to molecular friction.

Eddy currents – Small currents induced in a conducting core due to the variations in alternating magnetic flux.
End of Intro to Transformers