What is the Equivalent Circuit of Transformer?

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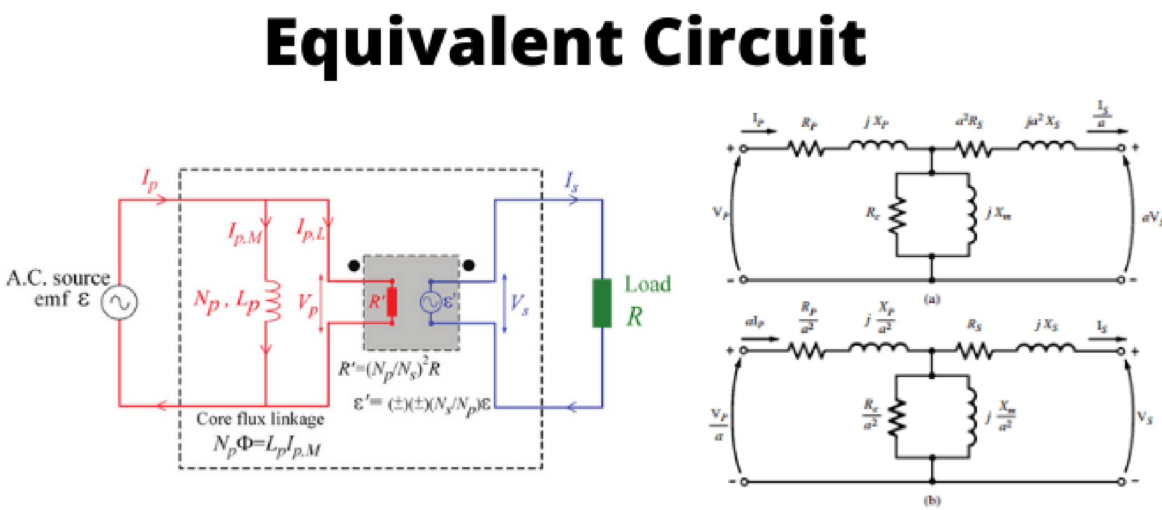

Equivalent Circuit of Transformer is an electrical circuit explanation of equations representing the behavior of that Transformer. In fact, an equivalent circuit of any electric instrument is important for the analysis of its performance and to discover any scope of further modification of modeling. The equivalent circuit of transformer includes a setup of inductance, resistance, voltage, capacitance, etc. These circuits can then be analyzed and explored by applying the principles of the diagram's theory.

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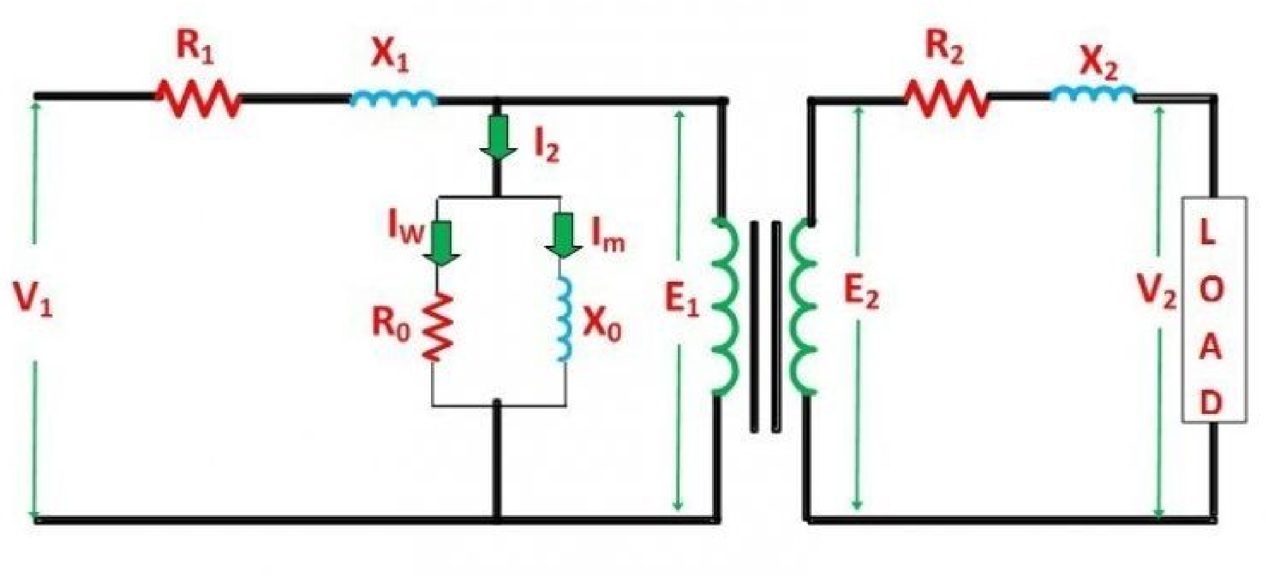
The equivalent circuit or diagram of any system can be relatively useful in the pre-specification of the performance of the instrument under the different situations of various operations. It can easily represent the circuit behavior by a particular equation describing the situation of the system completely.

For instance, equivalent impedance of the system is vital to be evaluated since the transformer is the electrical power instrument for considering several features of the electrical power device which may be needed to evaluate the whole internal impedance of the transformer in an electrical power system, exploring from primary or secondary side based on the requirement.

This estimation actually needs the equivalent circuit of transformer based on the basic side of the equivalent circuit of transformer and secondary side respectively. Relative impedance is also a very important characteristic of the transformer. Visit here to see the importance of this calculation in the design of any circuit.

The simplified equivalent circuit of a transformer is presented by considering all the properties of the transformer either on the primary or secondary side. The main equivalent circuit of the transformer is shown below in the diagram:



Equivalent Circuit of Transformer (Reference: **circuitglobe.com**)

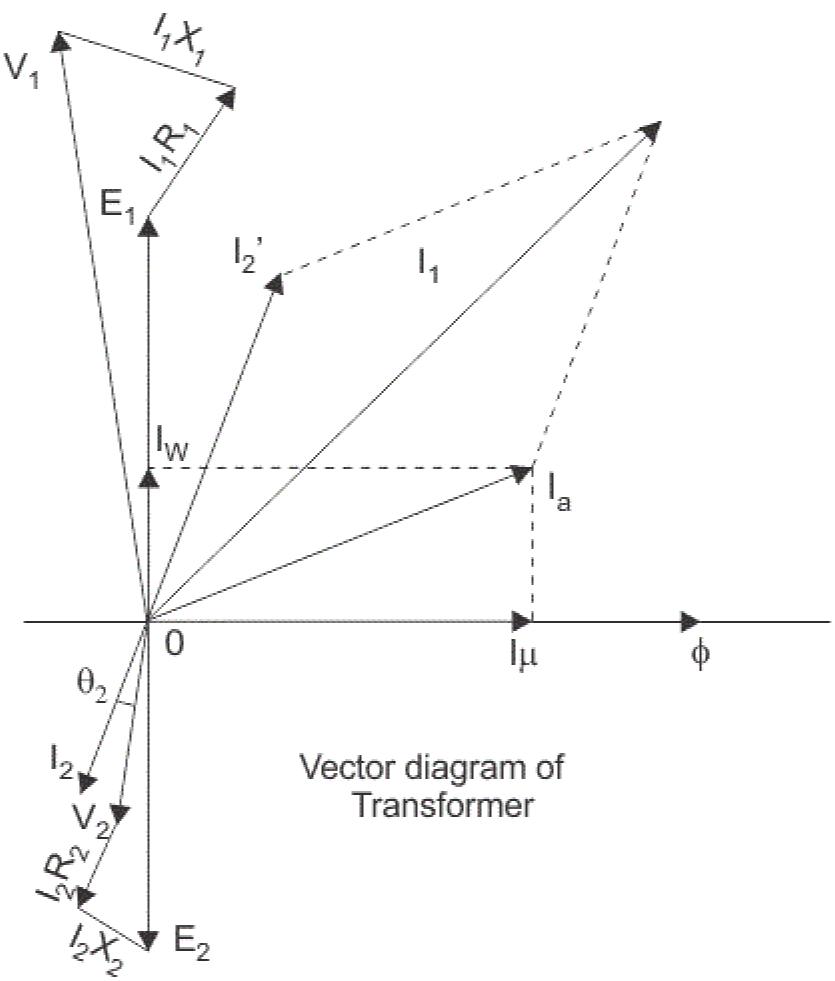
A high percentage of consideration is to be given to this feature for the installation of a transformer in an existing system of electrical power. The relative impedance of various power transformers must be completely matched based on the parallel configuration of power systems. The relative impedance can be extracted from the equivalent value of the transformer's impedance so, it can be noticed that the equivalent circuit of transformer is also important during the estimation of the relative impedance.

We can define the equivalent circuit of transformer based on the transformation ratio as:

$$K=\frac{{E}_{2}}{{E}_{1}}$$

Where E_1 is the induced emf equal to the main employed voltage (V_1) with a little voltage reduction. This voltage influences the system to produce the I_0 current or no-load current in the first winding of the transformer. The amount of no-load current is too little, and thus, it may be neglected in calculations.

We should primarily establish general rules in the system for driving the equivalent circuit of transformer, then, we can change it for preparing to define the rules based on the primary side. For this purpose, first, we require to present a full vector diagram of the transformer which is presented in the figure below.



Vector Diagram of Transformer (Reference: **electrical4u.com**)

As a result, $I_1 = I'_1$. The no-load current is further separated into two sections introduced as the magnetized current (I_m) and operating current (I_w).

These two sections of no-load current are based on the current derived from a non-inductive resistance R_0 and net reactance X_0 including voltage E_1 or (V_1: basic voltage reduction).

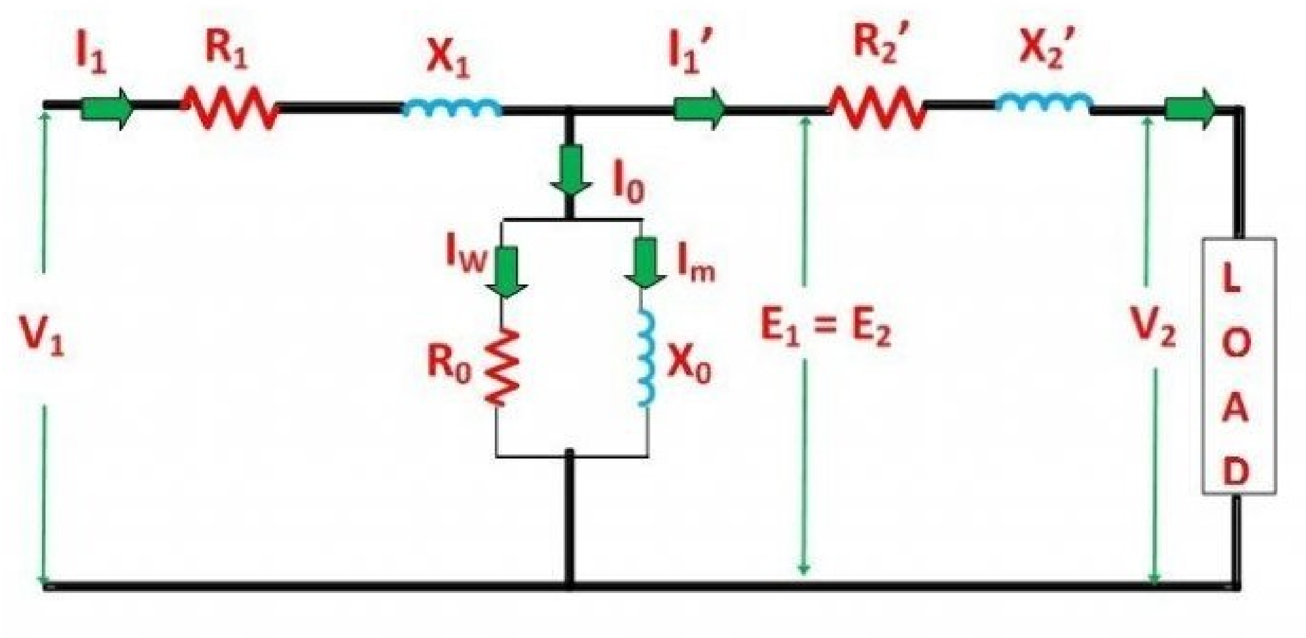
The second current I_2 can also be calculated by the next equation:

{I}_{2}=\frac{{I}_{1}^{'}}{K}=\frac{{I}_{1}-{I}_{0}}{K}

The connection voltage V_2 within the load is the same as the particular emf E_2 in the next winding with a little voltage reduction in the second winding.

Equivalent Circuit of Transformer when all the quantities are referred to Primary side

In this method, to derive the equivalent circuit of transformer, all the features are to be considered as the primary section as presented in the figure below:



Equivalent Circuit of Transformer Referred to Primary Side (Reference: **circuitglobe.com**)

The following quantities are the values of resistance and reactance that can be calculated by the next equations. Secondary resistance based on the primary side is obtained as:

$${R}_{2}^{'}=\frac{{R}_{2}}{{K}^{2}}$$

The equivalent resistance according to the primary consideration is obtained as:

$${R}_{ep}={R}_{1}+{R}_{2}^{'}$$

The second reactance based on the primary side is presented as:

$${X}_{2}^{'}=\frac{{X}_{2}}{{K}^{2}}$$

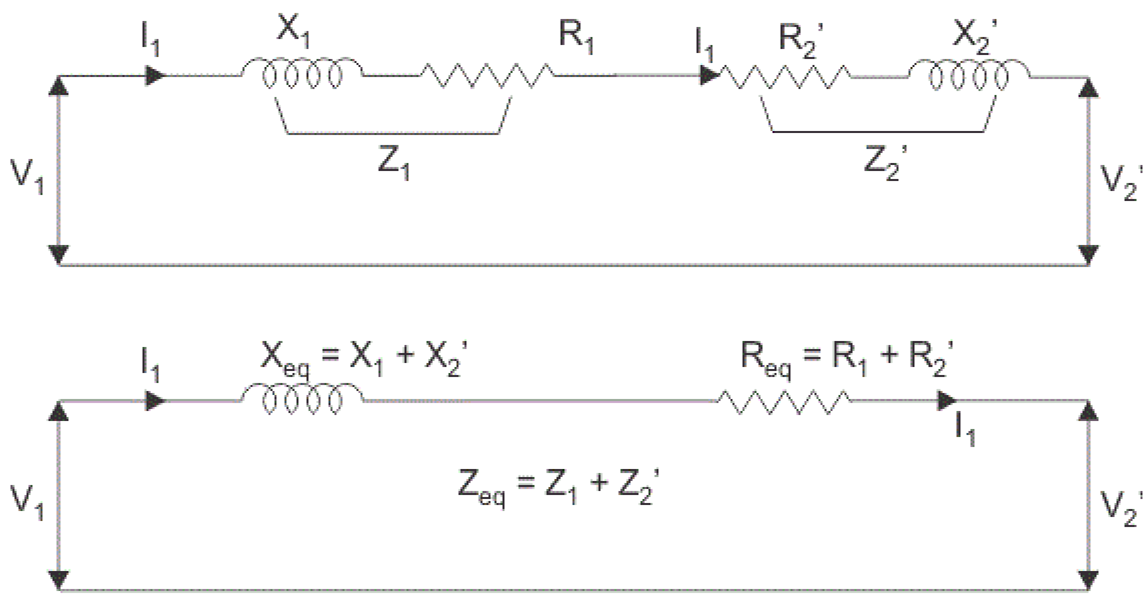
The equivalent reactance depends upon the primary side is obtained as:

$${X}_{ep}={X}_{1}+{X}_{2}^{'}$$

Approximate Equivalent Circuit of Transformer

Due to the small value of I_0 in comparison with I_1, it is less than 4 percent of the total load of the primary current and modifies the voltage reduction negligibly. As a result, it is a perfect approximation to reduce the excitation effect of the circuit in the approximate equivalent circuit of transformer method. The resistance and reactance of winding are arranged in a series configuration which can now be introduced as the equivalent reactance and resistance of transformer, based on any particular side. But in this method, it is the primary side or side 1 that determines the features of the circuit based on the next equation:

$${V}_{2}^{'}=K{V}_{2}$$



Approximate Equivalent Circuit of Transformer Referred to Primary Side (Reference: **electrical4u.com**)

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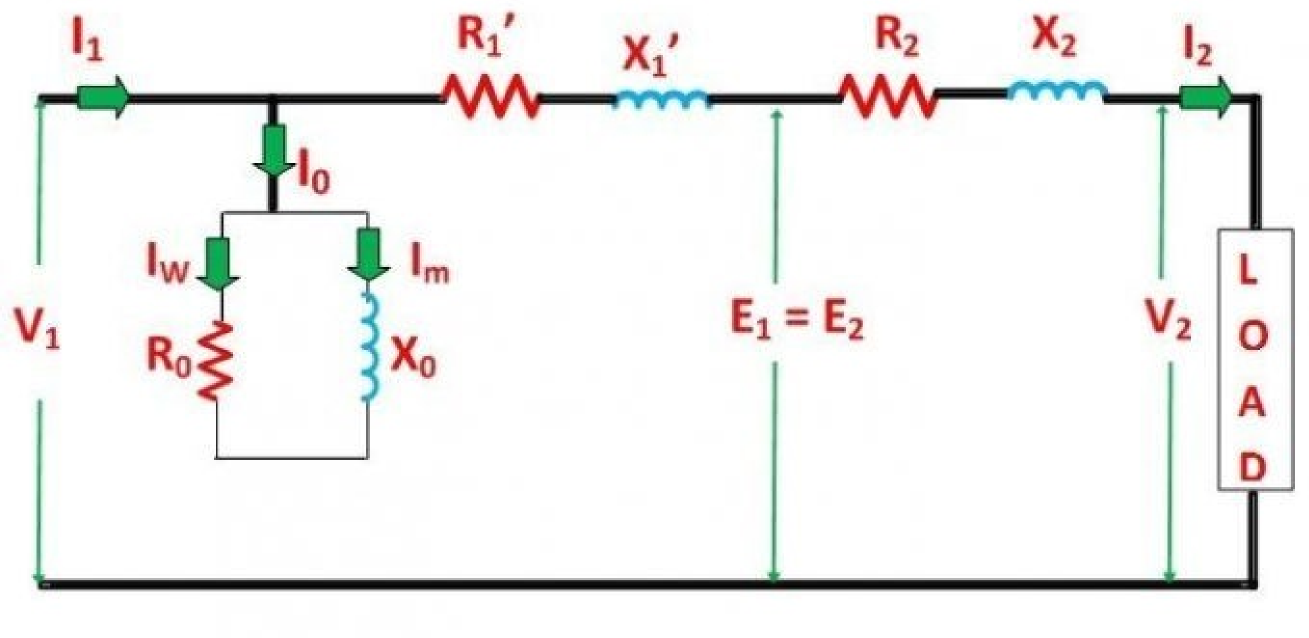
Equivalent Circuit of Transformer when all the quantities are referred to Secondary side

The equivalent circuit of transformer or the basic diagram is presented below when all the features are designed based on the secondary side.



Equivalent Circuit Referred to Secondary Side (Reference: **circuitglobe.com**)

The following properties are the values for resistance and reactance which can be obtained below. Basic resistance based on the secondary side is formulated as

{R}_{1}^{'}=K^{2}{R}_{1}

The equivalent value of resistance according to the secondary term is obtained as

$${R}_{es}={R}_{2}+{R}_{1}^{'}$$

The primary value of reactance based on the secondary side is presented as

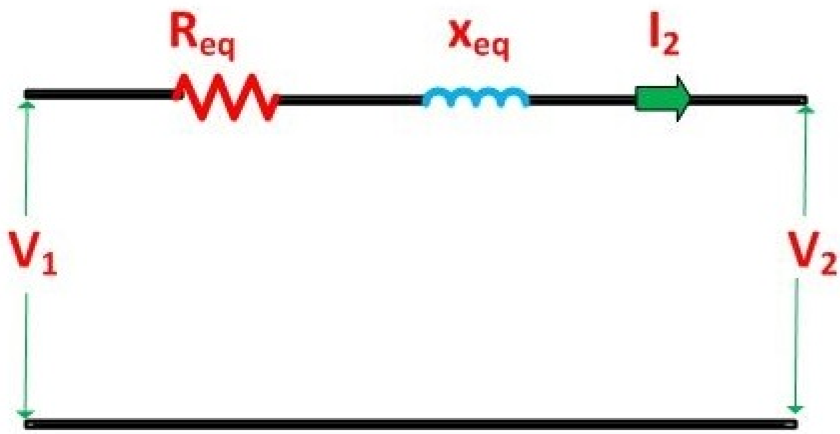
$${X}_{1}^{'}=K^{2}{X}_{1}$$

And the equivalent value of reactance is obtained as

$${X}_{es}={X}_{2}+{X}_{1}^{'}$$

Because the no-load current or I_0 is commonly 2 to 4 percent of the full load value of rated current, the parallel configuration includes the R_0 resistance and X_0 reactance can be removed from the circuit without introducing any particular error in the performance of the transformer when the load is applied.

We can also apply further simplification in the equivalent circuit of transformer by removing the parallel terms in the circuit including R_0 and X_0. This simplified diagram of the system is presented below:



Simplified Equivalent Circuit of Transformer (Reference: **circuitglobe.com**)

This is all considerable issues about the equivalent circuit of the Transformer.

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