

Transformer Capacity and Power Factor

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Abstract: The impact of Power Factor (PF) on transformer capacity is discussed for three different load types. The transformer's available power for consumption reduces with decreasing values of PF.

Power extraction from a transformer

Power Factor plays in an important role in extracting the most power from a transformer. Consider the system in Figure 1 where customer equipment is connected to a 600kVA transformer. What is the impact on the transformer? The relationship between PF, average power, reactive power, and apparent power is given by equation (1). The PF metric indicates the utilisation of average power from the total power extracted by the equipment from the transformer. Refer to the following scenarios.

$$PF = \frac{P}{S} = \frac{P}{V_{rms}I_{rms}} = \frac{P}{\sqrt{P^2 + Q^2}} \dots (1)$$

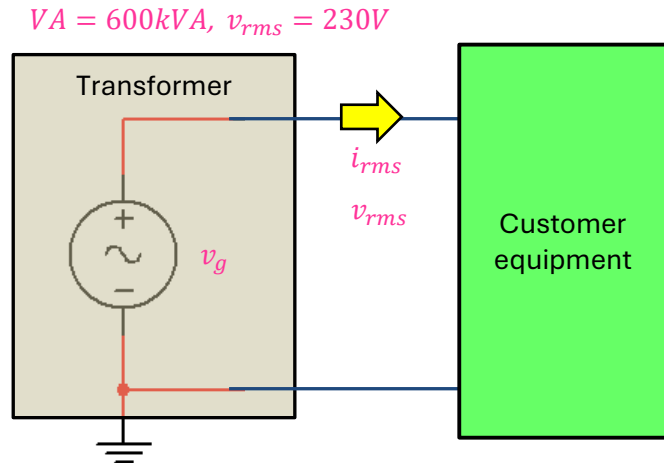


Figure 1: Customer equipment connected to a transformer

Scenario A: Resistive load

The customer equipment only draws 300kW. Using (1) the PF is unity since $P = 300kW$ and $Q = 0$. The remaining 300kVA, a capacity of 50%, is available to other customers.

Scenario B: Reactive load

In either case where the load is purely capacitive or inductive, from (1) the PF becomes zero since the $P = 0$ and $Q \neq 0$. Even though the load is not consuming any average power, instantaneous power is still required to energise and de-energise the reactive load. The available capacity of the transformer to other customers is hence reduced by an amount of reactive power Q .

Scenario C: Resistive and reactive load

The customer equipment only utilises 300kW but draws 500kVA due to an inductive load. Using (1) the PF is 0.6 lagging ($\frac{300}{500}$) due to inductive reactance and means that the customer equipment draws 500kVA but only utilises 60% of it for useful work ($300kW = 0.6 \cdot 500kVA$). The remaining power, 400kVar, is stored within the inductive element of the customer equipment and not available for consumption. More importantly, only 100kVA of transformer capacity (16.7%) remains available to other customers. The transformer could provide up to 300kVA, a capacity of 50%, to other customers if PF is unity.

Power Factor penalty charges

The utility hence imposes a penalty to a customer, if the PF level falls below its minimum requirement for the loss of opportunity to sell power to other customers. The minimum PF requirement is set by the electrical utility and can therefore vary.