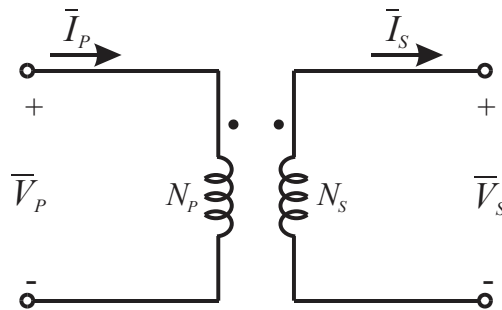


example- Autotransformer

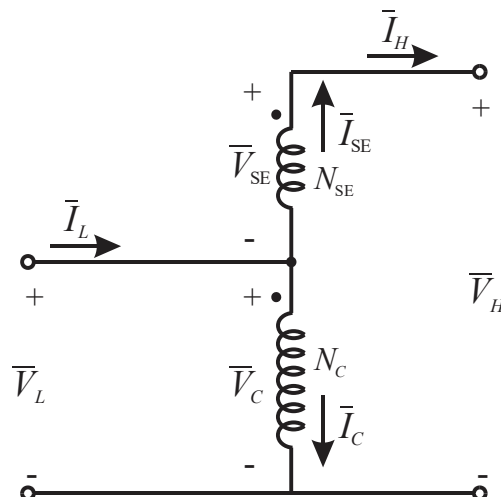
At 60 Hz, we need to step up from 208 V_{rms} to 240 V_{rms} with an apparent power rating of 5kVA at the terminals. Compare a conventional transformer to an autotransformer.

Conventional Transformer



- Calculate turns ratio (3-1) $a = N_p / N_s = V_p / V_s = 208 / 240 \Rightarrow \underline{a = 0.8667}$.
 $\Rightarrow \underline{N_p = 0.8667 N_s = 86.67\% \text{ of } N_s}$.
- Both coils and magnetic core need to be rated to **5 kVA**.
- Calculate rated current on 208 V_{rms} side as $I_{p,\text{rated}} = S_{\text{rated}} / V_p = 5,000 / 208$
 $\Rightarrow \underline{I_{p,\text{rated}} = 24.0385 \text{ A}_{\text{rms}}}$ (need 7 AWG for input wire & primary windings).
- Calculate rated current on 240 V_{rms} side as $I_{s,\text{rated}} = S_{\text{rated}} / V_s = 5,000 / 240$
 $\Rightarrow \underline{I_{s,\text{rated}} = 20.833 \text{ A}_{\text{rms}}}$ (need 8 AWG for output wire & secondary windings).

Autotransformer



- Here, (3-77) $V_L = V_C = 208 \text{ V}_{\text{rms}}$ and (3-78) $V_H = V_C + V_{\text{SE}} = 240 \text{ V}_{\text{rms}} \Rightarrow V_{\text{SE}} = V_H - V_C = 240 - 208 \Rightarrow \underline{V_{\text{SE}} = 32 \text{ V}_{\text{rms}}}$.
- Calculate the turns ratio using (3-83) $V_H/V_L = N_{\text{SE}}/N_C + 1 = 240/208$
 $N_{\text{SE}}/N_C = 240/208 - 1 \Rightarrow \underline{N_{\text{SE}}/N_C = 0.15385}$ or N_{SE} is 15.385% of N_C .
 (large savings on # of turns & length of wire needed for windings).
- The apparent power advantage (3-93)

$$\frac{S_{\text{IO}}}{S_W} = \frac{N_{\text{SE}} + N_C}{N_{\text{SE}}} = 1 + \frac{N_C}{N_{\text{SE}}} = 1 + 1 / 0.15385 = 1 + 6.5 \Rightarrow \underline{S_{\text{IO}} = 7.5 S_W}$$
- Therefore, for an input/output apparent power of 5 kVA, the apparent power of the autotransformer windings is $S_W = S_{\text{IO}} / 7.5 = 5000 / 7.5$
 $\Rightarrow \underline{S_W = 666.67 \text{ VA}}$ (7.5x lower or 13.3% of S_{IO} !).
- Rated current on 208 V_{rms} (low) side as $I_{L,\text{rated}} = S_{\text{rated}}/V_L = 5,000/208$
 $\Rightarrow \underline{I_{L,\text{rated}} = 24.0385 \text{ A}_{\text{rms}}}$ (need 7 AWG on input wire).
- Rated current on 240 V_{rms} side (high) side $I_{H,\text{rated}} = S_{\text{rated}}/V_H = 5,000/240$
 $\Rightarrow \underline{I_{H,\text{rated}} = 20.833 \text{ A}_{\text{rms}}}$ (need 8 AWG on output wire).
- However, these are not the actual currents in the windings of the autotransformer. Per (3-90), $S_W = V_C I_C = V_{\text{SE}} I_{\text{SE}}$.
 $\Rightarrow I_{C,\text{rated}} = S_W / V_C = 666.67/208 \Rightarrow \underline{I_{C,\text{rated}} = 3.205 \text{ A}_{\text{rms}}}$ (need 16 AWG).
The common windings on the autotransformer can be much lighter than the conventional transformer!
 $\Rightarrow I_{\text{SE},\text{rated}} = S_W / V_{\text{SE}} = 666.67/32 \Rightarrow \underline{I_{\text{SE},\text{rated}} = I_{H,\text{rated}} = 20.833 \text{ A}_{\text{rms}}}$ (8 AWG).

Summary-

The autotransformer needs much less winding length (i.e., $N_C + N_{\text{SE}} < N_P + N_S$), can have lighter common windings (i.e., N_C can be 16 AWG), and have a lighter magnetic core (i.e., S_W is 13.3% of S_{rated}).