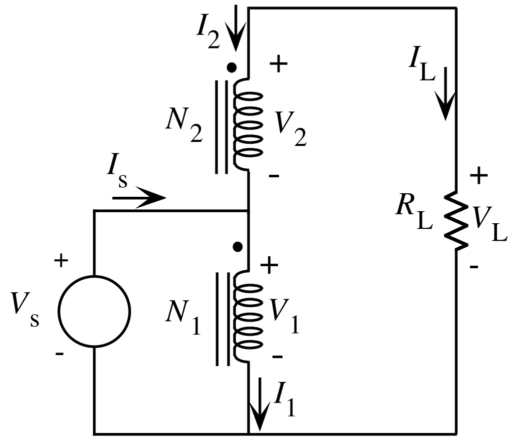
Auto Transformer Example

For the autotransformer setup shown below, we find the following values of voltages and currents.



$$V_1 = V_s \quad , \quad V_2 = \frac{N_2}{N_1} V_1 = \frac{N_2}{N_1} V_s$$

$$V_L = V_1 + V_2 = V_S + \frac{N_2}{N_1} V_S = V_S \left[1 + \frac{N_2}{N_1} \right]$$

$$I_2 = -I_L = \frac{-V_L}{R_L} = \frac{-V_S}{R_L} \left[1 + \frac{N_2}{N_1} \right]$$

$$I_1 = -\frac{N_2}{N_1} I_2 = \frac{V_S}{R_L} \frac{N_2}{N_1} \left[1 + \frac{N_2}{N_1} \right]$$

From these voltages and currents, we find the following load and source powers:

$$P_L = V_L I_L = \frac{V_S^2}{R_L} \left[1 + \frac{N_2}{N_1} \right]^2$$

$$P_s = -V_s I_s = - -\frac{V_S^2}{R_L} \left[1 + \frac{N_2}{N_1} \right]^2 = -P_L \quad \text{(which we sould expect)}$$

We can also find the powers delivered to the two transformer windings:

$$P_1 = V_1 I_1 = -\frac{V_S}{R_L} \frac{N_2}{N_1} \left[1 + \frac{N_2}{N_1} \right] = \frac{N_2 / N_1}{1 + N_2 / N_1} \text{x} P_L$$

$$P_2 = V_2 I_2 = \frac{V_s^2}{R_L} \frac{N_2}{N_1} \left[1 + N_2/N_1 \right] = \frac{-N_2/N_1}{1 + N_2/N_1} \text{x} P_L = -P_1 \quad \text{(which we sould expect)}$$

For a step-down configuration ($-2 > N_2 /N_1 < 0$), notice that $|P_1 /P_L| < 1$ when $N_1 > 2|N_2|$, which means that the winding powers are less than the load power. This means that the transformer power rating can be less than the load power. The same thing occurs for the step-up configuration when $N_1 > 0$ and $N_2 > 0$.

The plot the below shows P_1 /P_L as a function of N_2 /N_1, where negative values of N_2 /N_1 correspond to the reversal of one of the transformer dots. The autotransformer is step-down when $-2 > N_2 /N_1 < 0$ and step-up when $N_2 /N_1 > 0$ or $N_2 /N_1 < -2$. This plot shows that P_1 can be either positive or negative, depending on the turns ratio and the winding polarities.