3–12 An autotransformer is used to connect a 12.6-kV distribution line to a 13.8-kV distribution line. It must be capable of handling 2000 kVA. There are three separate autotransformers, connected Y–Y with their neutrals solidly grounded.

a. What must the N_C/N_{SE} turns ratio be to accomplish this connection?

b. How much apparent power must the windings of each autotransformer handle?

c. If one of the autotransformers were reconnected as an ordinary transformer, what would its ratings be?

a) Per (2-11), the high and low side phase voltages for Y-configuration are

$$V_H = V_{LL,H} / \sqrt{3} = 13{,}800 / \sqrt{3} = 7967.4337 \ (\mathrm{V_{rms}}) \text{ and}$$

$$V_L = V_{LL,L} / \sqrt{3} = 12{,}600 / \sqrt{3} = 7274.6134 \ (\mathrm{V_{rms}}).$$

Per (3-83), $\dfrac{V_L}{V_H} = \dfrac{N_C}{N_C + N_{SE}} \Rightarrow \dfrac{V_H}{V_L} = \dfrac{N_C + N_{SE}}{N_C} = 1 + \dfrac{N_{SE}}{N_C} \Rightarrow \dfrac{N_C}{N_{SE}} = \left(\dfrac{V_H}{V_L} - 1\right)^{-1}.$

$$\frac{N_C}{N_{SE}} = \left(\frac{7967.4337}{7274.6134} - 1\right)^{-1} \Rightarrow \underline{\boldsymbol{N_C / N_{SE} = 10.5}}.$$

b) The power advantage for a single autotransformer is given by (3-93)

$$\frac{S_{IO}}{S_W} = \frac{N_{SE} + N_C}{N_{SE}} = 1 + \frac{N_C}{N_{SE}} = 1 + 10.5 = 11.5.$$

Now, each autotransformer must be able to handle a third of the overall $S_{tot} = 2000$ kVA $\Rightarrow S_{IO} = 2000/3$ kVA = 666.667 kVA. Therefore, each winding will need to handle

$$S_W = \frac{S_{IO}}{11.5} = \frac{666.667}{11.5} \Rightarrow \underline{\boldsymbol{S_W = 57.971 \text{ kVA}}}.$$

c) The step-up autotransformer has $V_L = 7274.6134 \ (\mathrm{V_{rms}})$ across the common winding N_C.

Per (3-78) and Figure 3-31b, the step-up autotransformer has

$$V_{SE} = V_H - V_C = V_H - V_L = 7967.4337 - 7274.6134 = 692.82 \ (\mathrm{V_{rms}})$$

across the series winding N_{SE}.

We have the apparent power as 57.97 kVA from step b.

So, the overall ratings when connected as a regular transformer would be

$$\Rightarrow \underline{\boldsymbol{7274.6/692.8 \ V_{rms} \text{ and } 57.97 \text{ kVA}}}.$$