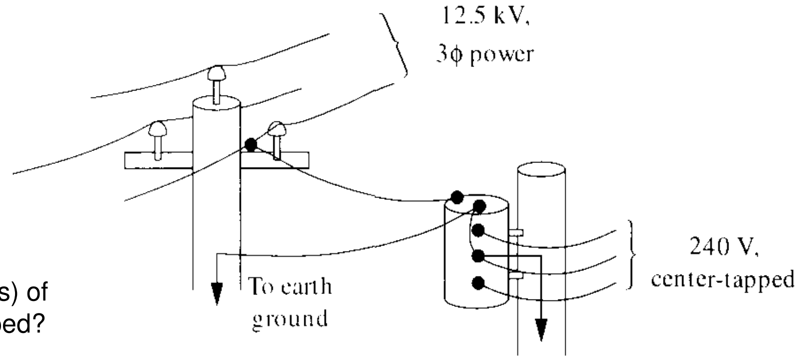
ECE 3600 homework # 13

Do the circled problems on both front and back.



1. 1.19. The city of Austin, Texas. distributes power with a three-phase system with 12.5 kV between the power-carrying wires. But each group of houses is served from one phase and ground, and transformed to 240/120 V by a pole transformer, as shown.

   a) What is the turns ratio (primary/secondary turns) of the pole transformer to give 240 V, center-tapped?

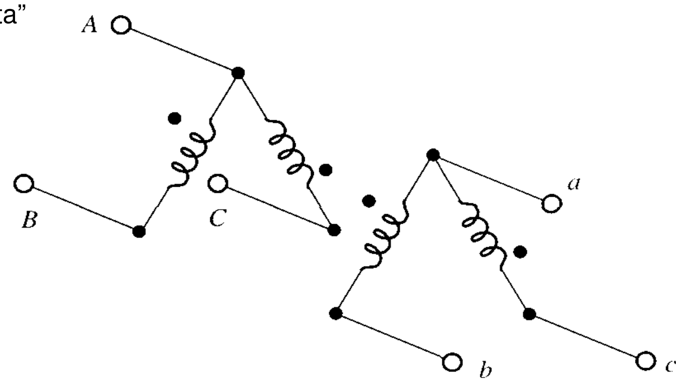
   b) When a 1500-W hair dryer is turned on, how much does the current increase in the high-voltage wire? Assume the power factor is unity and the transformer is 100% efficient.

In the text, we showed how to transform three-phase power with the use of three single-phase transformers. There are two ways to transform three-phase power with two single-phase transformers. The next two problems investigate these methods. In them, we will transform 460 V three phase to 230 V three phase; hence, the transformers have a turns ratio of 2:1. Hint: In both figures, the geometric orientation hints of the phasor relationships.

2. 1.21. The configuration shown is called the “open-delta” or "V" connection, for obvious reasons. Identical 2:1 transformers are used.

   a) Show that if ABC is 460-V balanced three phase, abc is 230-V balanced three-phase. Consider the ABC voltages to be a three-phase set and prove the abc set is three-phase.

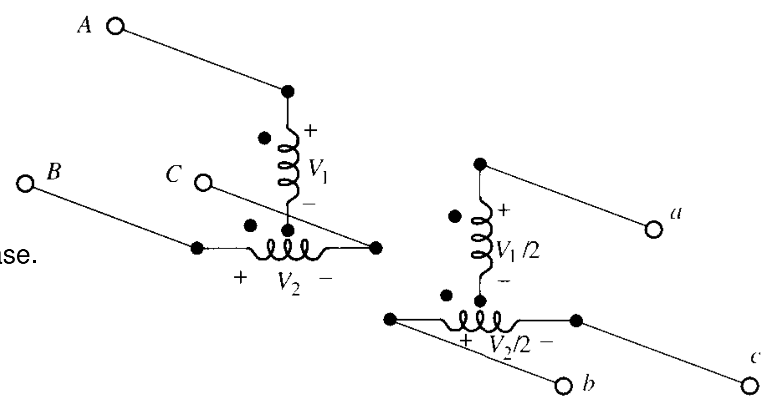
   b) If the load is 30 kVA, find the required kVA rating of the transformers to avoid overload. [You can solve this independent of part a)]



3. 1.22. The configuration shown is called the "T" connection. For this connection, the 2:1 transformers are not identical but have different voltage and kVA ratings. The bottom transformer is center-tapped so as to have equal, in-phase voltages for each half.

   a) Find the voltages V_1 and V_2 to make this transform 460-V to 230-V balanced three-phase.

   b) If the load is 30 kVA, find the required kVA rating of each transformer to avoid overload.



4. 5.1 A single-phase transformer is designed to operate at 60 Hz. Its voltage ratings are: primary, 500 V; secondary, 200 V. The maximum permissible load is 30 kVA.

   a) What will be the magnitudes of primary and secondary currents when the device is full-loaded?

   b) Loading is accomplished by an impedance connected across the 200-V terminals. How many ohms will correspond to full-load of the transformer? (Use IT model.)

5. 5.3 The 30-kVA transformer of the problem above is made subject to a SC test. One winding is short-circuited and the other winding is fed from a 60-Hz voltage source. The voltage is raised until rated current is circulated in the windings. This occurs when the applied voltage equals 5.11% of rated winding voltage. The transformer consumes 290 W during the test.
   a) Compute the series impedance $\mathbf{Z_s} = R_s + jX_s$ of the transformer referred to primary and secondary sides.
   b) Compute the core flux during the SC test. (Express its magnitude in percent of normal operating flux.)
   c) Why is it permissible to assume that all of the 290 W constitute ohmic losses in R, and no part of it is core loss?

6. 5.5 The transformer in Exercise 5.3 is fed from a 500-V source. A load impedance of $Z_L := (1.03 + j\cdot 0.72)\cdot\Omega$ is connected across the secondary.
   a) Find the currents in both windings and the secondary voltage by use of the IT model.
   b) Same as in part a) but now include the transformer impedance in your analysis.
   Take note of the change in your answers.

7. 5.7 The 500/200-V, 30-kVA transformer above is reconnected as a 700/500-V autotransformer.
   Compute the new kVA rating of the device.

8. 5.8 The terminals of the 500/200-V windings in the previous transformer can be interconnected in four different ways, two of which will result in a 700/500-V autotransformer. Assume that you have interconnected the windings in the wrong way, but that you are of the belief that you did it the right way. In other words, you think that you have a 700/500-V autotransformer when in fact you have something else. As you now connect the "700-V terminals" of your device to a 700-V source, you expect to obtain 500-V between what you presume to he "500-V terminals." To your surprise you get an entirely different voltage.
   a) What voltage do you get?
   b) What will happen to your transformer with this kind of treatment?

Answers

1. a) 30.07 b) $208\cdot mA$
2. a) Calculate $\mathbf{V_{bc}}$ from the other two voltages and show that it has the correct magnitude and correct phase angle,
   b) $17.3\cdot kVA$ per transformer, $34.6\cdot kVA$ for both
3. a) $398\cdot 4\cdot V$ $460\cdot V$ b) $15\cdot kVA$ $17.3\cdot kVA$ $32.3\cdot kVA$ for both
4. a) $60\cdot A$ $150\cdot A$ b) $1.333\cdot\Omega$
5. a) $0.0806 + 0.418\cdot j\cdot\Omega$ $0.0129 + 0.0669\cdot j\cdot\Omega$ b) 5.11% of normal rated value.
   c) Because the core flux is 5.11% of normal rated value, the core losses (which are approximately proportional to the square of the flux) are negligible.
6. a) $63.66\cdot A$ $159.2\cdot A$ b) $61.23\cdot A$ $153.1\cdot A$ c) Yes, a little
7. $105\cdot kVA$
8. a) $1167\cdot V$ b) The smoke gets out