

Branch Circuit Calculations

by Gerald Newton
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1. A 20 ampere, 120 volt, 2-wire branch circuit has a maximum load capacity of _____ watts or volt-amperes.

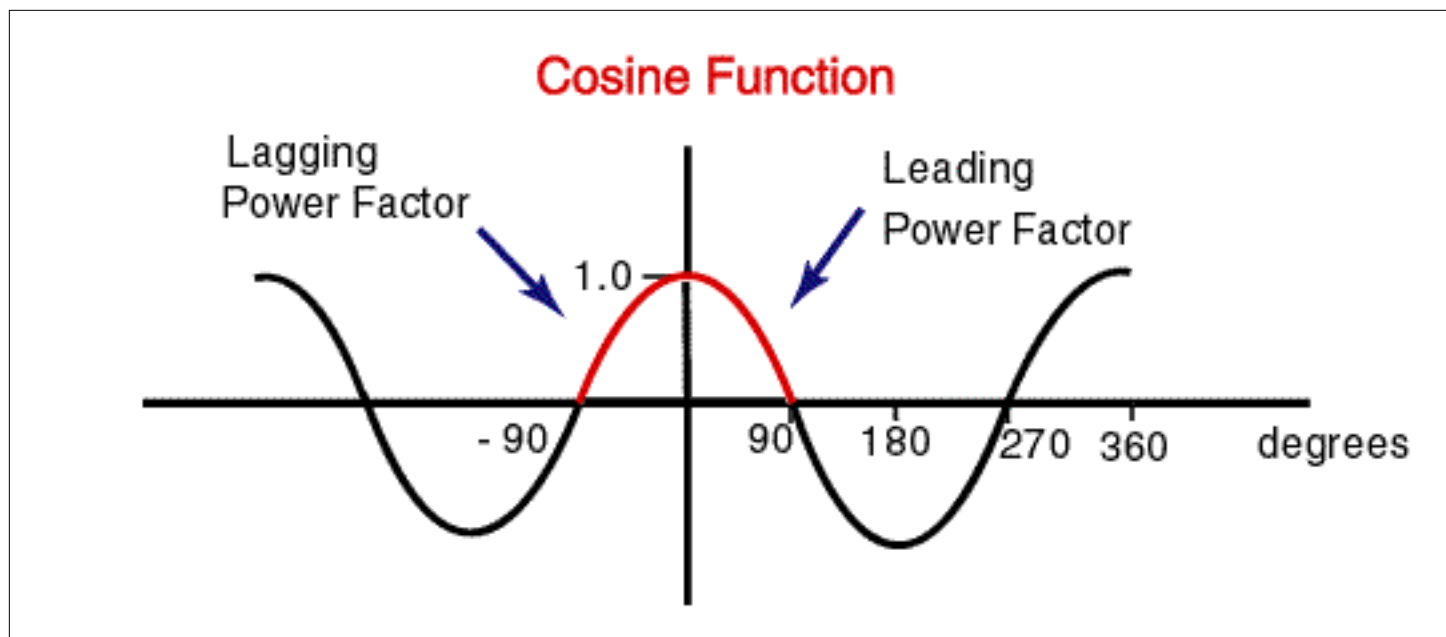
Reference:

Using the following for Single Phase Circuits:

Watts = Volts x Amperes x Power Factor

Volt-amperes = Volts x Amperes

Power Factor is the cosine of the angle between volts and amperes and varies from 0 to 1.0, lagging or leading.



Answer:

Assuming that the voltage and current are in phase, the angle between the voltage and current is 0 degrees, and the Cosine of 0 is 1.0, then the power factor is 1.0. then Watts = 120 x 20 x 1.0 Watts = 2400 At a power factor of 1.0, Watts and Volt-amperes are equal and volt-amperes is also 2400.

Answer: 2400

2. A 5-kilowatt clothes dryer has a full-load current of _____ amperes when connected to a 120/240 volt, single phase 3-wire supply circuit. The minimum size of circuit (rating of the overcurrent device) that can be used on this circuit is _____ amperes, with a minimum wire size of No. _____ copper (assuming a 60 degrees C. ampacity and no listing for higher temperature devices and equipment.)

Reference:

Using the following for Single Phase Circuits:

Watts = Volts x Amperes x Power Factor

Assume a power factor of 1.0

Amperes = Watts/Volts

Answer:

Amperes = 5,000 watts/240volts

Amperes = 20.8 amperes

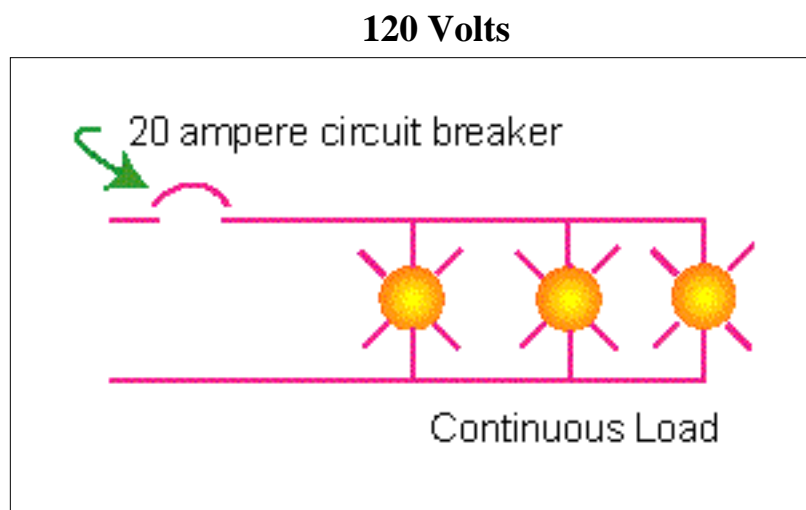
The minimum size overcurrent device that can be used on this circuit is 25 amperes. (see 240-6)

A minimum size No. 10 copper rated at 30 amperes is required. (Table 310-16)

Note: The 60 C. ampacity for No. 12 is 25 amperes, but Section 240-3(d) does not allow a No.12 conductor on a circuit breaker greater than 20 amperes.

Answers: 20.8 amperes, 25 amperes, No. 10

3. The maximum continuous load permitted on a 20 ampere, 120 volt, 2-wire branch circuit supplying incandescent lighting that stays on for three hours or more is _____ watts. (Assume that the circuit breaker is not listed for 100 percent continuous load at its rating)



Reference:

Section 210-20(a) The rating of the overcurrent device shall not be less than 125 percent of the continuous load.

Answer:

The solution to this problem and many Code calculations can be simplified by converting the language into mathematical terms. Then rules from algebra for inequalities can be used to solve the problems.

Use ">=" to represent "greater than or equal to"

Use "<=" to represent "less than or equal to"

"shall not be less than" is the same as "greater than or equal to" represented by ">="

Then:

Rating of Overcurrent Device $\geq 1.25 \times$ Continuous load

Continuous Load \leq Rating of Overcurrent Device / 1.25

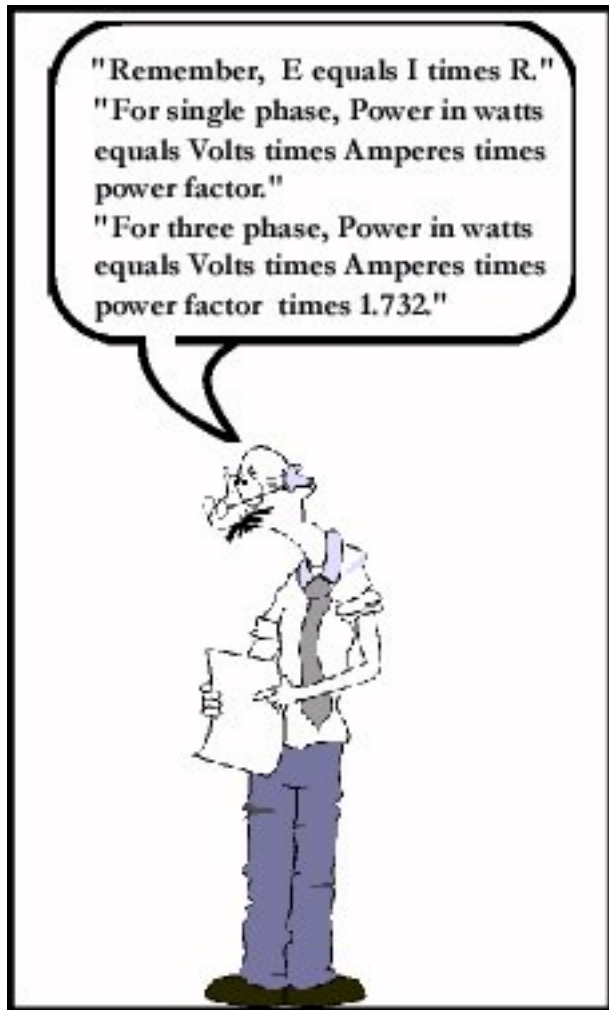
Continuous Load ≤ 20 amperes / 1.25

Continuous Load ≤ 16 amperes

Converting 16 amperes to Watts: Watts = 16 amperes x 120 volts

Watts = 1920 watts

Answer: 1920 watts



4. If the wattage of a single phase 120 volt appliance is given, then the full-load current can be found using the formula $I = \frac{Watts}{Volts}$.

Answer: $I = \frac{Watts}{120volts}$

5. An 800 watt 120-volt car heater will draw a load of _____ amperes.

Answer: $I = \frac{Watts}{Volts}$

$I = \frac{800 \text{ watts}}{120 \text{ volts}}$

$I = 6.7 \text{ amperes}$

6. A 80 gallon 4500 watt 240 volt hot water heater has a load of _____ amperes. This load is less than 20 amperes, but Section 422-13 requires that fixed storage-type water heaters that have a capacity of 120 gallons or less shall have a branch circuit rating not less than 125 percent of the nameplate rating of the water heater. The branch circuit rating then must not be less than _____. Since the load for this appliance is more than 13.3 amperes and it is a nonmotor-operated appliance that does not have overcurrent protection marked on the appliance the overcurrent rating shall not exceed 150 percent of the appliance rated current

by section 422-11(e)(3). In this case the rating of the circuit breaker shall not greater than _____. However, section 422-11(e)(3) states that if 150 percent of the appliance rating does not correspond to a standard size overcurrent device, the next larger standard size shall be permitted. So the overcurrent device shall be permitted to be _____ amperes maximum size. The rules for selecting conductors are found in Section 210-19(a) and 240-3. The conductors shall have an ampacity not less than the load to be served or 18.75 amperes, and shall be protected in accordance with their ampacities as specified in 310-15. Section 240-3(d) limits the overcurrent protection for a No. 10 copper conductor to 30 amperes. This assumes a 60 degree C. temperature rating. If the equipment, terminations, and overcurrent devices are listed for 75 degree C., then a No. 10 conductor would still be required since Section 240-3(d) does not allow a No. 12 with a 75 degree C. ampacity of 25 amperes to be used on a 30 ampere circuit breaker. A No. 10 copper conductor with a 25 ampere two-pole circuit breaker would also meet these rules.

Answers: 18.75 amperes, 23 amperes, 28 amperes, 30 amperes.

7. If a 277 volt fluorescent lighting fixture has a ballast with a nameplate rating of .9 amperes, the number of such fixtures that can be connected to a 2 wire 277 volt circuit

protected by a 20 ampere circuit breaker is _____ if the fixtures are used in an office building where they will be on for 8 hours continuously each day.

Answer: The maximum allowed continuous ampacity for the 20 ampere circuit breaker is 16 amperes. $16/.9 = 17$ fixtures.

Answer: 17

8. The maximum number of 100 watt incandescent light bulbs that can be installed on a 20 ampere 120 volt 2 wire circuit where the lights will be on for 10 hours a day is _____.

Answer:

Amperes for each light bulb = 100 watts / 120 volts

Amperes = .8

$1.25 \times .8 = 1.0$ amperes (Multiply by 1.25 for the continuous load.)

20 amperes / 1.0 amperes = 20 light bulbs

Answer: 20

9. Section 220-3(b)(9) requires that receptacles in other than dwelling units be computed at 180 voltamperes each. The maximum number of receptacles that can be installed on a 20 ampere 120 volt circuit in a store is _____. The maximum number of receptacles that can be installed on a 15 ampere 120 volt circuit in a school is _____.

Answer:

Number of receptacles on a 20 ampere circuit = 120 volts x 20 amperes / 180 voltamperes

Number of receptacles on a 20 ampere circuit = 13

Number of receptacles on a 15 ampere circuit = 120 volts x 15 amperes / 180 voltamperes

Number of receptacles on a 15 ampere circuit = 10

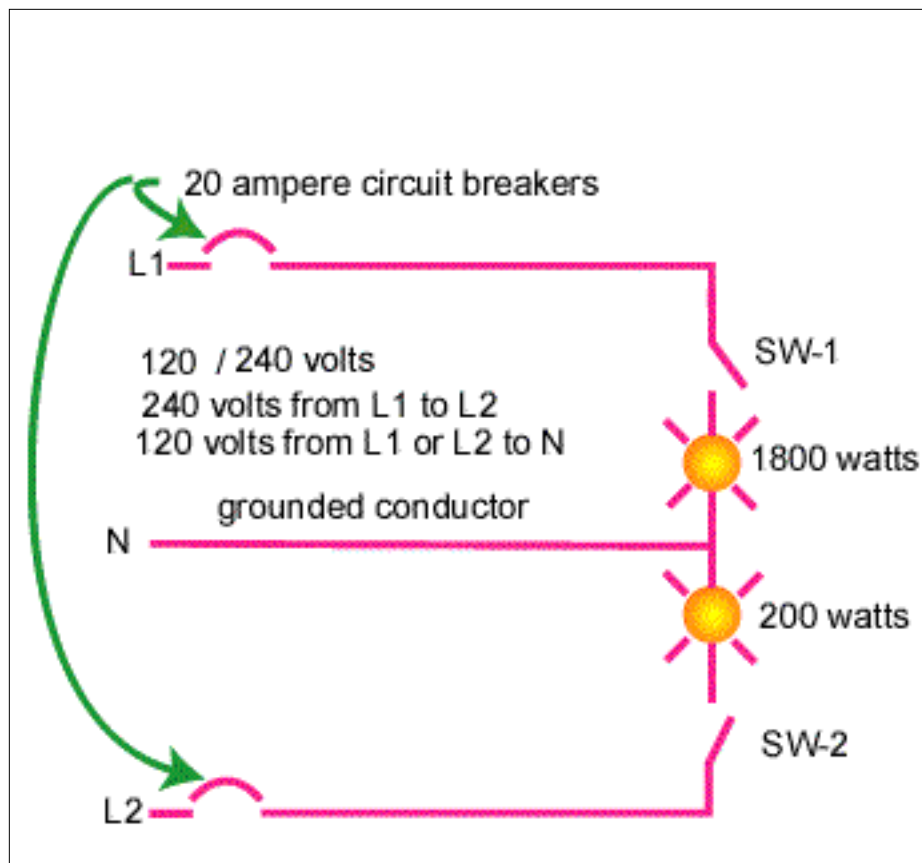
10. In dwelling units and in guest rooms of hotels and motels all receptacles used for general-use on 20 ampere rating or less circuits including the small appliance receptacles, laundry room receptacle and bathroom receptacle(s) are included in the general lighting load calculations of Section 220-3(a). These receptacles shall not be required to be calculated at 180 voltamperes per receptacle.

True ____

False ____

Answer: False The small appliance circuits are not included in the the general lighting load calculation. See Section 220-3(b)(9) and (10)

11. In the sketch below if SW-1 is closed how many amperes will L1 and the grounded conductor draw?



SKETCH 3

Answer: Load = 1800 watts

Amperes = watts / volts

Amperes = 1800 watts / 120 volts

Amperes = 15 amperes

Answer: 15 amperes

12. In Sketch 3, the resistance of the 1800 watt load is _____. The resistance of the 200 watt load is _____.

Answer: $E=IR$ by ohms law. $R=E/I$, Then the resistance is 120 volts / 15 amperes

Resistance of the 1800 watt load is 8 ohms

For the 200 watt load, first find the amperes. Amperes = 200 watts / 120 volts, Amperes = 1.7 amperes.

Resistance = 120 volts / 1.7 amperes

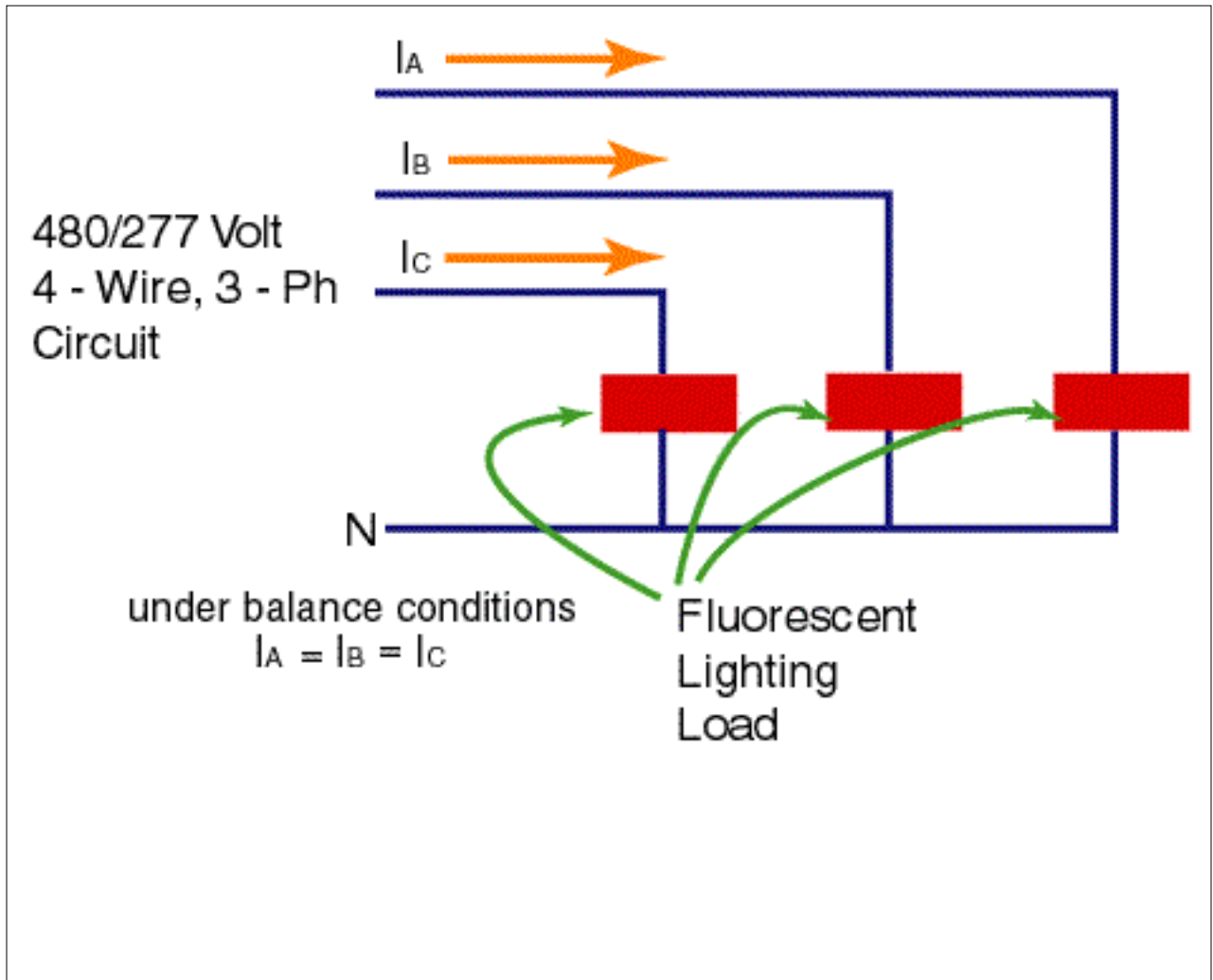
Resistance of the 200 watt load is 70.6 ohms

13. In sketch 3 if the grounded conductor were open and both the 1800 watt load and the 200 watt load were turned on what would the voltage be across the 200 watt load?

Answer: If the grounded conductor were open the two loads would be in series. The 8 ohm and 70.6 ohm resistances in series add to 78.6 ohms. The amperes through both loads would be 240 volts / 78.6 ohms or 3 amperes. The voltage across the 200 watt load would be 70.6 ohms x 3 amperes or 211.8 volts.

Answer: 211.8 volts

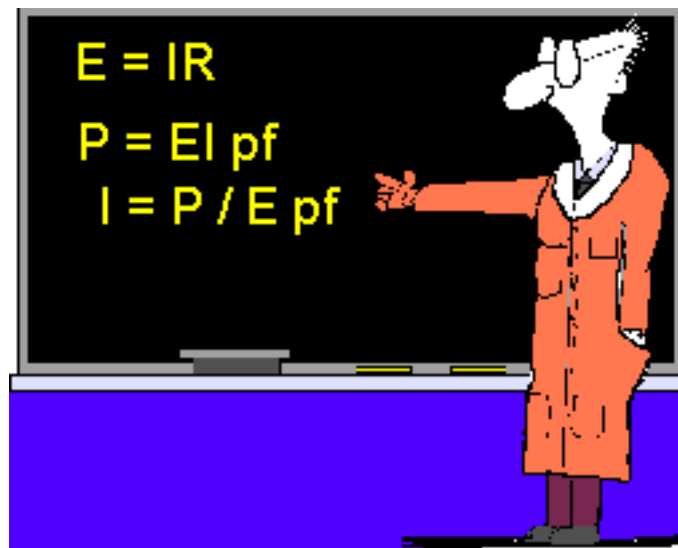
14. In the diagram below I_A , I_B , and I_C can be found using _____?



- A. $I = \text{Watts} / (277 \text{ volts} \times 1.732)$
- B. $I = \text{watts} / 3$
- C. $I = \text{watts} / (480 \text{ volts} \times 1.732 \times \text{power factor})$

Answer: C

"The Single Phase Professor"



15. In the diagram for question 14, if each leg serves 1/3 of a balanced load of 10,000 voltamperes then what is the current in each leg ? Assume that the power factor is 1.0.

**Answer: $I = 10,000 \text{ voltamperes} / (480 \text{ volts} \times 1.732)$
 $I = 12 \text{ amperes}$**

16. The minimum number of 20 ampere 120 volt branch circuits required to serve the general lighting load for a 3,000 square foot one family dwelling unit is _____ circuits.

**Answer: General Lighting load = 3 voltamperes x 3,000 square ft.
 General Lighting Load = 9,000 voltamperes.
 A 20 ampere circuit supplies 120 volts x 20 ampere or 2400 voltamperes.
 $9,000 \text{ voltamperes} / 2400 \text{ voltamperes} = 3.75$
 Round up to 4 circuits
 Answer: 4 circuits**

16. In a dwelling unit at least two 20 ampere, 120 volt circuits must be provided for laundry outlets.

**True _____
 False _____**

Answer: False See Section 210-52(f)

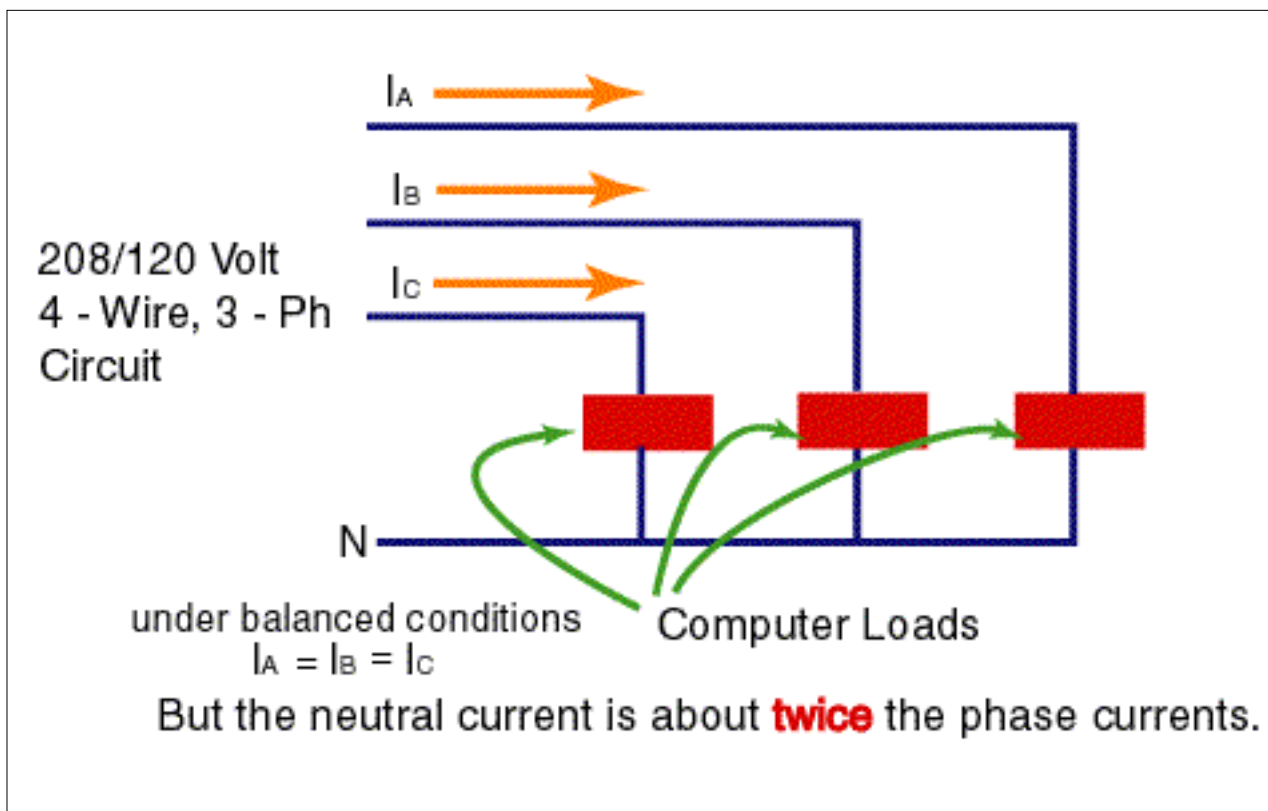
17. The receptacles installed to serve countertop surfaces in dwelling unit kitchens shall be supplied by two each small appliance circuits.

**True _____
 False _____**

Answer: True See 210-52(b)(3)

Note: One small appliance circuit cannot be used to supply all the receptacles for countertops while another small appliance circuit is used to supply the other required outlets in the dining room, pantry, kitchen, breakfast room, or similar area in a dwelling unit.

18. In the diagram below the 120 volt loads are computer loads. If the line current in each phase is 40 amperes, the approximate current in the neutral is _____.



Answer: 80 amperes

Discussion: The switching in the computer power supplies cause the current in the neutral to be approximately double the current in the phase conductors. Special cables and "K" rated transformers are designed to supply such loads.

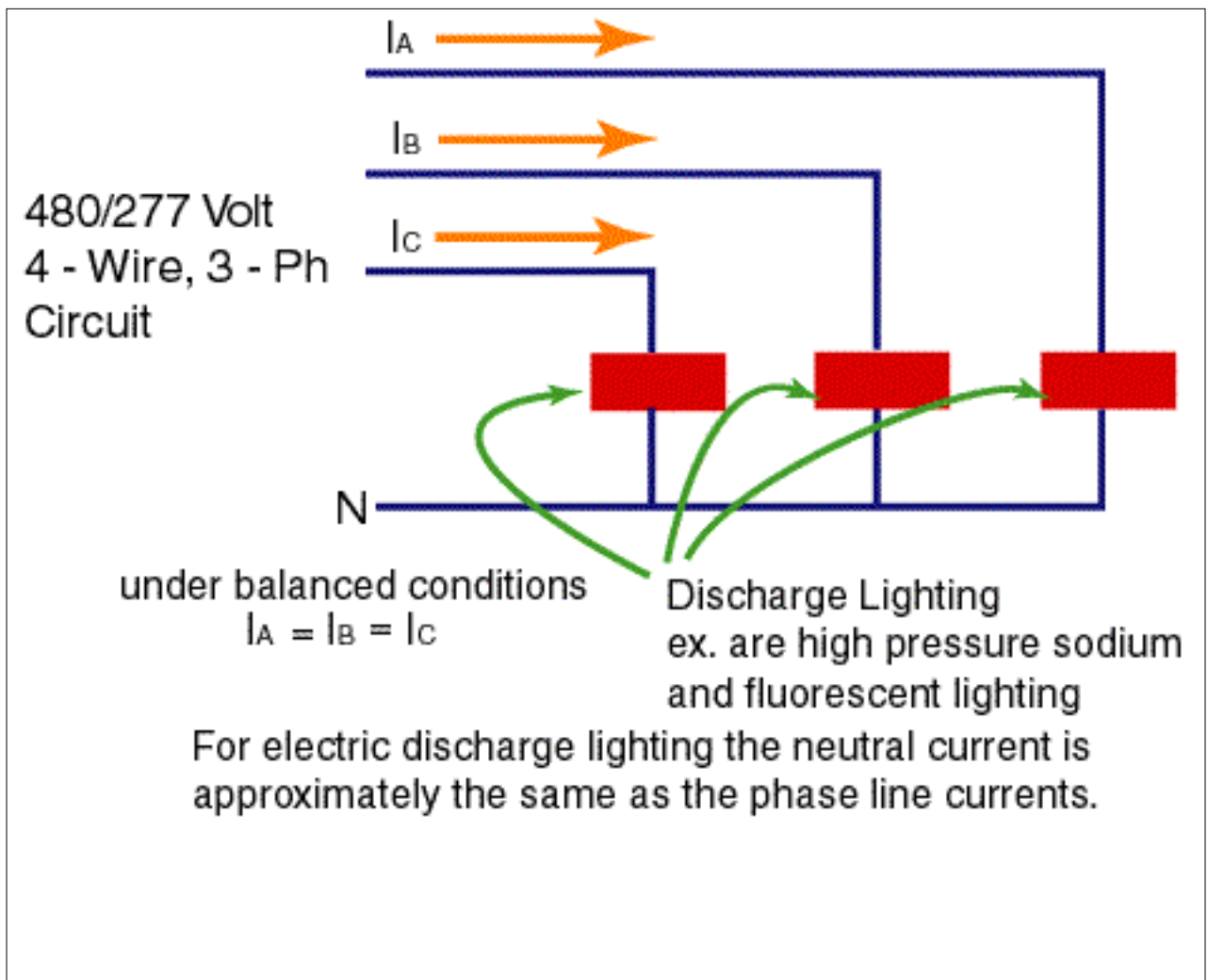
19. In the diagram below for derating purposes the neutral is a current carrying conductor.

True _____

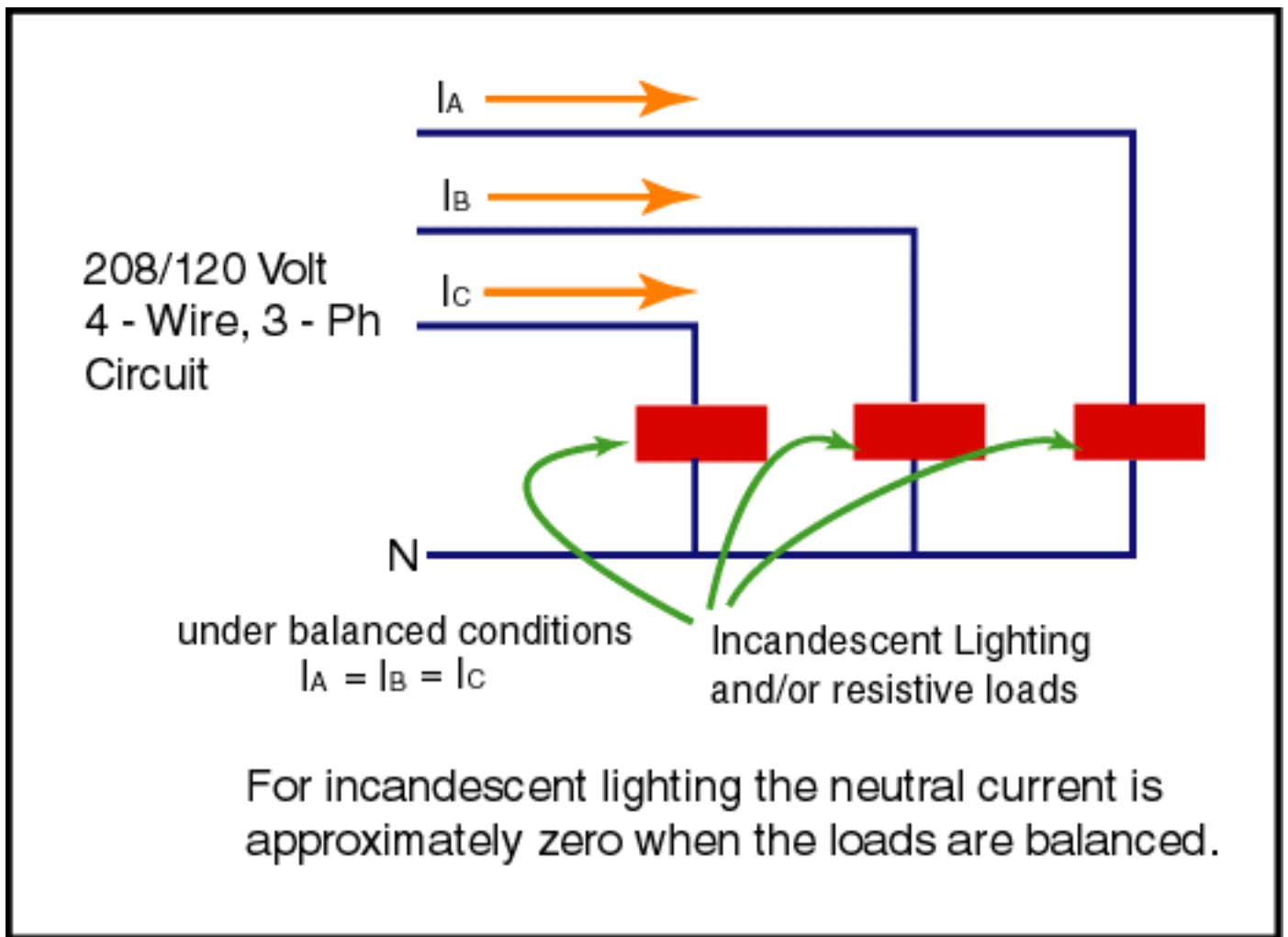
False _____

Answer: True See Section 310-15(b)(4)(c)

Discussion: When the major load is nonlinear the neutral carries third harmonic currents that are approximately equal to the line currents.



20. In the diagram below if I_a , I_b , and I_c are equal to 50 amperes the current in the neutral is approximately _____ amperes.



Answer: 0 amperes

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