PIQ Quiz Notes

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Bus Bar Quiz 2

Determining cross-sectional area for laminated bus bars

A properly sized conductor will minimize temperature rise and also can be sized to ensure a desired voltage drop. Calculating the cross-sectional area based on voltage drop will be addressed in a future quiz.

In this exercise we will learn how to approximate the cross-sectional area of a single copper conductor in still air, based on a required current. This approximation is based on a ambient temperature of 30°C and a 30°C temperature rise and can be used for currents up to 300 amps. In this exercise we will use three different methods to approximate the cross-sectional area. All three methods will yield the same results:

- Based on a current density
- Based on a known formula
- From a table

Answers in orange.

Determining cross-sectional area based on a current density

In this approximation, we can assume the following current densities:

- 4.8 amps / square millimeter (mm^2)
- 3000 amps / square inch (in^2)

For question one:

- Required current = 150 amps
- We will use a simple proportion to solve for the area: 3000 amps is to 1 in^2 as 150 amps is to X

$$\frac{3000 \text{ amps}}{1 \text{ in}^2} \quad x \quad \frac{150 \text{ amps}}{X}$$

$$X = \frac{150 \text{ amp-in}^2}{3000 \text{ amp}} = 0.05 \text{ in}^2$$

Question 1: Using current densities, what is the cross-sectional area for 225 amps?

A. 0.04 in^2

B. 0.06 in^2

C. 0.075 in^2

Explanation

- Area (X) in^2 = 225 / 3000 = .075 in^2

Determining cross-sectional area based on a known formula

Known formula:

- Area (in^2) = I (amps) x .00033

For question two:

- Required current = 150 amps
- Area (in^2) = 150 (0.00033) = 0.0495 in^2

Question 2: Using the known formula, what is the cross-sectional area for 80 amps?

A. 0.015 in^2

B. 0.026 in^2

C. 0.033 in^2

Explanation

- Area = 80 x 0.00033 = .026 in^2

Determining cross-sectional area using the table method

Another method to determine cross-sectional area is the table method. Using the table, it's easy to calculate the area in square inches required to carry fifty amps.

Wire Size Gauge	Thickness (in)	Width (in)	Current Capacity (amps)	DC Resistance 2 Conductor (milliohm/ft)
11	0.01	0.646	19.54	2.53
10	0.01	0.815	24.62	2
9	0.015	0.685	31.1	1.59
8	0.015	0.865	39.35	1.26
7	0.015	1.09	49.6	1
6	0.02	1.032	62.4	0.792
5	0.02	1.3	78.6	0.628
4	0.03	1.092	99.2	0.5

Under the "Current Carrying (amps)" column, go down to the 49.6 amp row.

- Thickness = 0.015 inches
- Width = 1.09 inches

We know that area in square inches equals width multiplied by thickness. In this case, the area is equal to 0.015 x 1.09 which equals 0.016 in^2.

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Question 3: Using the table method, what is the cross-sectional area for 200 amps?

A. 0.033 in^2

B. 0.050 in^2

C. 0.066 in^2

Explanation

Under the “Current Carrying (amps)” column, go down to the 99.2 amp row.

Wire Size Gauge	Thickness (in)	Width (in)	Current Capacity (amps)	DC Resistance 2 Conductor (milliohm/ft)
4	0.03	1.092	99.2	0.5

- Thickness = 0.030 inches
- Width = 1.092 inches

Area = 0.030 x 1.092 = 0.033 in^2

Note: This calculation is for 100 amps. Because you need the area for 200 amps, multiply the above area by 2.

Area = 0.033 x 2 = 0.066in^2

Conclusion

Now that you know the area required to carry the current, you can easily calculate the material thickness or conductor width using the following formula:

Area (in^2) = W (Conductor Width) x T (Conductor Thickness)

T = A / W or W = A / T

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- Cooling of Power Electronics Solutions Guide
- R-Tools 3D Heatsink Thermal Modeling Tool

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