

CURRENT DENSITY

TECHNICAL EXPLANATION

**SMALLER
CROSS-SECTION**

High current density



**Strong
heating**



**High losses
Overload risk**

$$J = \frac{I}{A}$$

J = Current density [A/mm²]

I = Current [A]

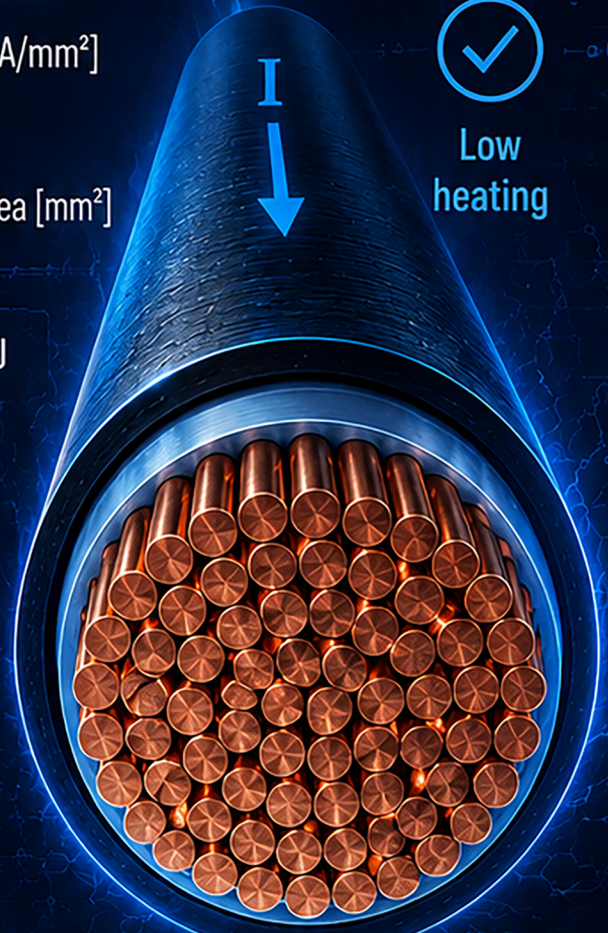
A = Cross-sectional area [mm²]

**LARGER
CROSS-SECTION**

Low current density



**Low
heating**



**Low losses
Safe operation**

Current density J



CURRENT DENSITY

Technical Explanation



1 WHAT IS CURRENT DENSITY?

When electric current flows through a conductor, electrical energy is converted into heat. This heating effect has a significant impact on the service life of the insulation. Excessive current leads to higher losses, dangerous overheating of the conductor and can damage equipment or even cause fires.



In this analysis, it is assumed that in metallic conductors the charge carriers are evenly distributed across the entire cross-section (DC and AC with low frequency).

2 CURRENT AND CROSS-SECTION



The current I depends on the amount of charge Q passing through the cross-section in a given time t .

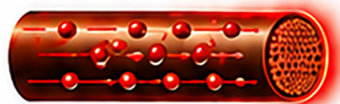


The larger the cross-sectional area A , the more charge carriers are available and the same current can flow.

● Free charge carriers → Direction of current flow

3 WHY SMALLER CROSS-SECTIONS CAN CARRY MORE CURRENT

For the same current, charge carriers must move faster in a smaller cross-section. Higher speed means more collisions in the conductor material and therefore more heat. However, the ratio of the cooling surface (outer surface) to the cross-section is better for small conductors than for large ones. As a result, smaller conductors can withstand higher current densities.



1 Smaller cross-section
fewer, faster charge carriers
→ high current density



2 Larger cross-section
more, slower charge carriers
→ low current density

Fig. 1.2 Different current density at the same current

4 TYPICAL CURRENT DENSITIES (GUIDELINES)

	Building wiring	2 ... 6	$\frac{A}{mm^2}$
	Overhead lines	3 ... 9	$\frac{A}{mm^2}$
	Transformers	1,5 ... 3.5	$\frac{A}{mm^2}$
	Incandescent lamps	... 500	$\frac{A}{mm^2}$



WARNING

If the current density becomes too high at a constant cross-section, the conductor heats up excessively and the insulation may be damaged – risk of fire!

5 WHAT DOES THE ALLOWABLE CURRENT DENSITY DEPEND ON?

The maximum allowable current density is determined by the conductor's ability to dissipate heat. Important influencing factors are:

- Type and thickness of insulation
- Installation method
- Ambient temperature





CURRENT DENSITY

TECHNICAL EXPLANATION



2 DEFINITION AND FORMULA

The current density J describes how much current I flows through a certain cross-sectional area A .

$$J = \frac{I}{A}$$

J = Current density [A/mm²]

I = Current [A]

A = Cross-sectional area [mm²]

3 UNITS



$$\frac{A}{\text{mm}^2}$$

Current density



[A]

Current



[mm²]

Cross-sectional area

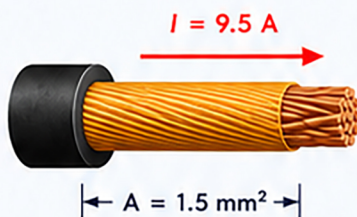
4 EXAMPLES

Example 1 Given: Current density J

Given:

$$I = 9.5 \text{ A}$$

$$A = 1.5 \text{ mm}^2$$



$$\begin{aligned} J &= \frac{I}{A} \\ &= \frac{9.5 \text{ A}}{1.5 \text{ mm}^2} \\ &= 6.33 \text{ A/mm}^2 \end{aligned}$$

$$\text{Result: } J = 6.33 \text{ A/mm}^2$$

Example 2 Given: Current I

Given:

$$J = 3.33 \text{ A/mm}^2$$

$$A = 12 \text{ mm} \times 5 \text{ mm} = 60 \text{ mm}^2$$



$$\begin{aligned} I &= J \cdot A \\ &= 3.33 \frac{\text{A}}{\text{mm}^2} \cdot 60 \text{ mm}^2 \\ &= 199.8 \text{ A} \approx 200 \text{ A} \end{aligned}$$

$$\text{Result: } I = 200 \text{ A}$$

5 FORMULA SUMMARY

$$J = \frac{I}{A}$$
$$\frac{A}{\text{mm}^2} = \frac{A}{\text{mm}^2}$$

$$A = \frac{I}{J}$$
$$\text{mm}^2 = \frac{\text{A}}{\text{A/mm}^2}$$

$$I = J \cdot A$$
$$A = \frac{A}{\text{mm}^2} \cdot \text{mm}^2$$



SUMMARY

Current density is an important key value in electrical engineering. It helps in selecting the correct conductor cross-sections and ensures a safe and efficient system.

Always observe the permissible values according to applicable standards and regulations!

LEARN MORE WITH ELEKTROKURSE

MAKING ELECTRICAL ENGINEERING EASY TO UNDERSTAND

$$J = \frac{I}{A}$$

J = Current density [A/mm²]

I = Current [A]

A = Cross-sectional area [mm²]



EXPERT CONTENT

Well-structured texts explained in a clear and simple way.



PRACTICAL EXERCISES

Strengthen your understanding with targeted exercises.



HELP & SUPPORT

Helpful tips and solutions for your learning journey.



STEP-BY-STEP

Learn complex topics step by step – easy to follow.

▶▶▶ CONTINUE LEARNING ONLINE NOW! ◀◀◀



ANYTIME.
ANYWHERE.



LEARN TODAY.
BUILD YOUR FUTURE.

elektrokurse.de/et-module