Application Note PE018

Field Geometry

At a straight, infinite, current flow conductor the lines of field are circular around the center of the conductor. This means that the strength of the magnetic field is constant at a circle around the conductor.

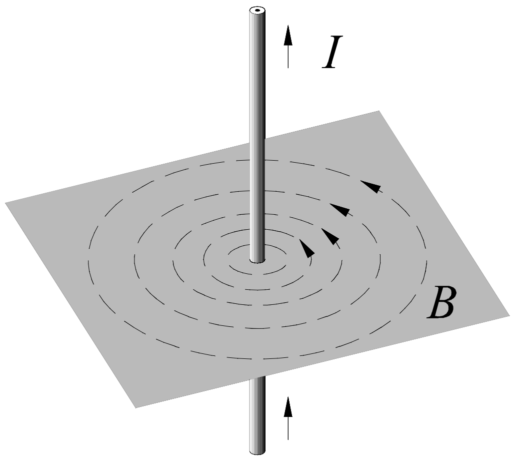

Figure 1: field of a conductor

The direction of the field is given by the “Right Hand Grip Rule”. For further information also see our application note PE004 “Magnetic Field Basics”.

Formula

For the magnetic field outside of a straight, infinite, current flow conductor the following formula applies:

(1) $$H(r) = \frac{I}{2\pi r}$$

Here r is the distance to the center of the conductor and I is the current flowing in the conductor.

With the material formula of electrodynamics the conversion to magnetic flux density can be made:

(2) $$B = \mu H$$

For air with a μ_r of 1 the μ simplifies to

(3) $$\mu = \mu_r \mu_0$$

(4) $$\mu = \mu_0$$

So this results to

(5) $$B(r) = \mu_0 \frac{I}{2\pi r}$$

If the following value of μ_0

(6) $$\mu_0 = 4\pi \cdot 10^{-7} \frac{T \cdot m}{A}$$

is inserted into formula (5), it results in

(7) $$B(r) = 4\pi \cdot 10^{-7} \frac{T \cdot m}{A} \frac{I}{2\pi r}$$

(8) $$B(r) = 2 \cdot 10^{-7} T \cdot {}^{I}\!/_{A} \cdot \frac{1}{{}^{r}\!/_{m}}$$

Example

Assume a conductor carrying 100 A. What is the magnetic flux density in a distance of 1 cm from the center of the conductor.

For this formula (8) is uses. Inserting the given values we get the following:

(9) $$B(0{,}01\,\mathrm{m}) = 2\cdot 10^{-7}\,\mathrm{T}\cdot 100\,\frac{\mathrm{A}}{\mathrm{A}}\cdot\frac{1}{0{,}01\,\frac{\mathrm{m}}{\mathrm{m}}}$$

This results in:

(10) $$B(0{,}01\,\mathrm{m}) = 2\cdot 10^{-7}\,\mathrm{T}\cdot 100\cdot 100$$

(11) $$B(0{,}01\,\mathrm{m}) = 2\cdot 10^{-3}\,\mathrm{T}$$

(12) $$B(0{,}01\,\mathrm{m}) = 2\,\mathrm{mT}$$

If additionally a current density is assumed

(13) $$J = 2\frac{\mathrm{A}}{\mathrm{mm}^2}$$

this results in the following section area of the conductor

(14) $$A = \frac{I}{J}$$

(15) $$A = \frac{100\mathrm{A}}{2\frac{\mathrm{A}}{\mathrm{mm}^2}}$$

(16) $$A = 50\,\mathrm{mm}^2$$

With the area of a circular section

(17) $$A = \pi r^2$$

it results in

(18) $$r = \sqrt{\frac{A}{\pi}}$$

(19) $$r = \sqrt{\frac{50\,\mathrm{mm}^2}{\pi}}$$

(20) $$r \approx 4\,\mathrm{mm}$$

The flux density had been calculated for a distance of 10 mm from the center of the conductor. From the surface of the conductor this are just 6 mm.

Graphic Chart

In the following chart the flux density is plotted in dependence of the distance for different currents.

Additionally the surface of the conductor is marked for different current densities.

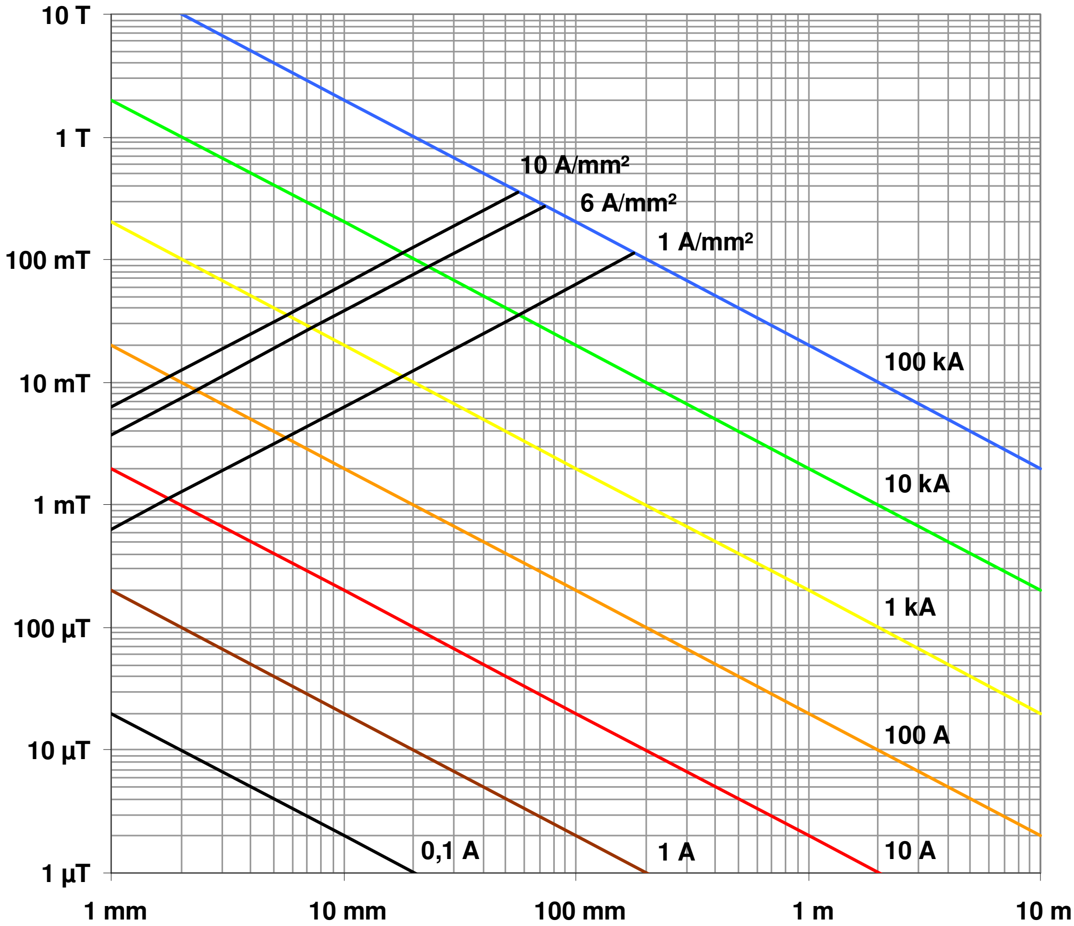

Figure 2: flux density in dependence of current and distance

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