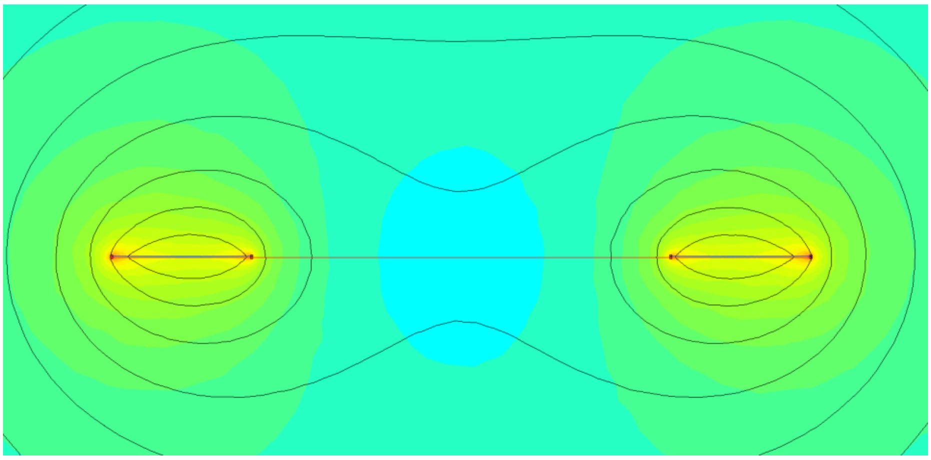
2D Comparison COMSOL (blue) and FEMM (black diagrams) results

Two flat traces with 20um x 5mm and in between 15mm distance

20A applied at both traces respectively.

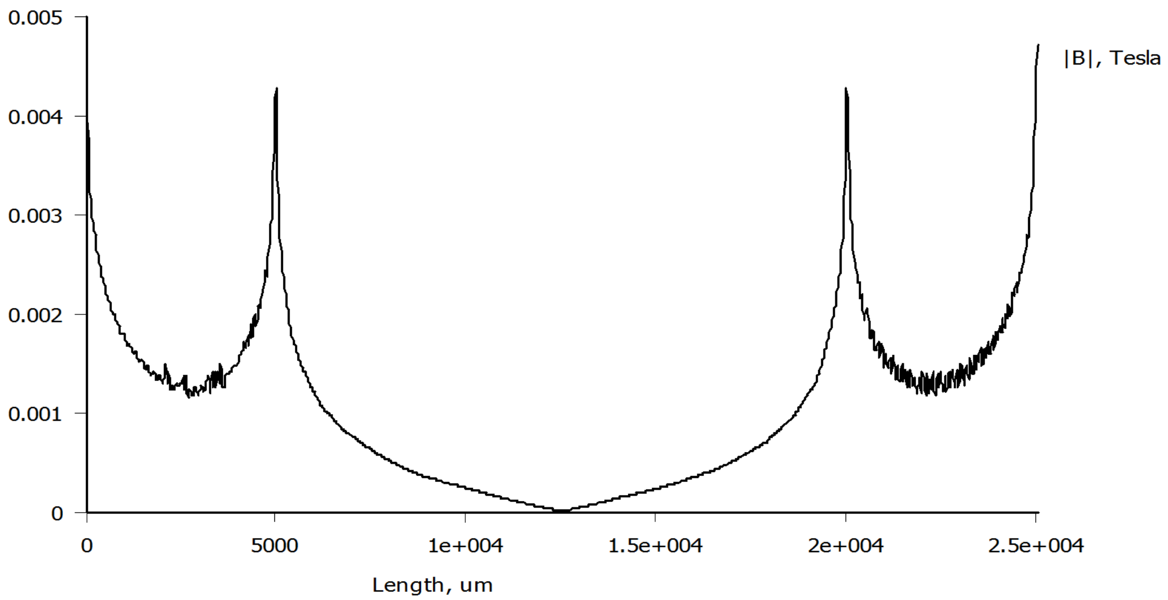
Material properties are the same as in COMSOL

10kHz distribution with cut (red)

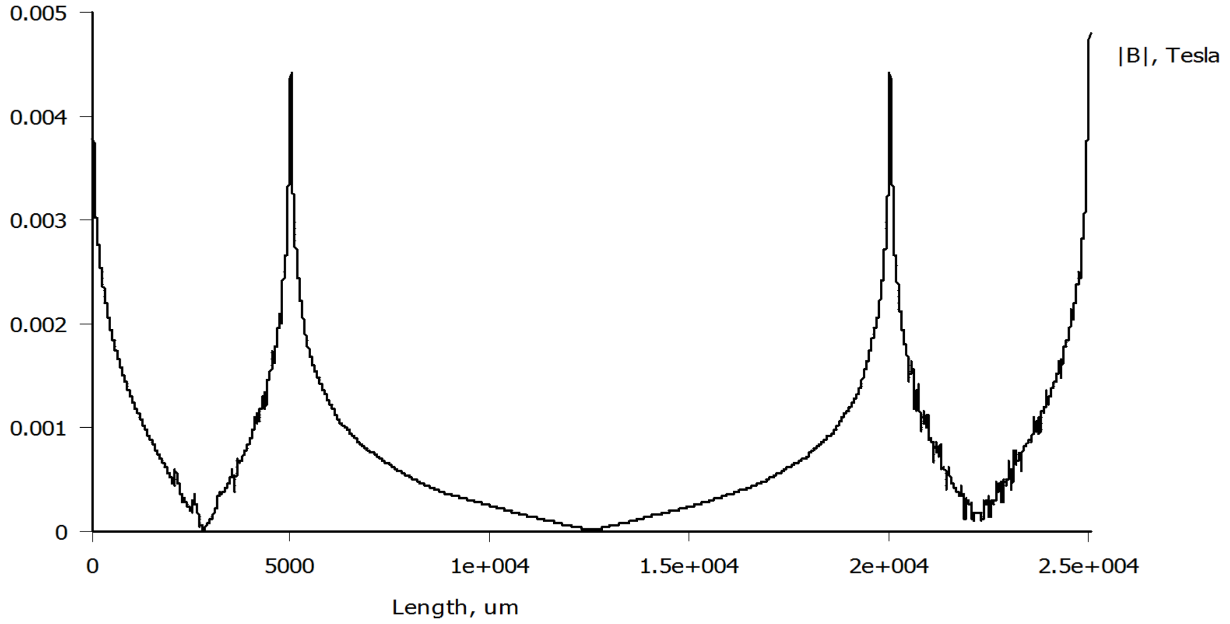


The following diagrams show the norm of the magnetic flux density at a cut along the horizontal of the traces

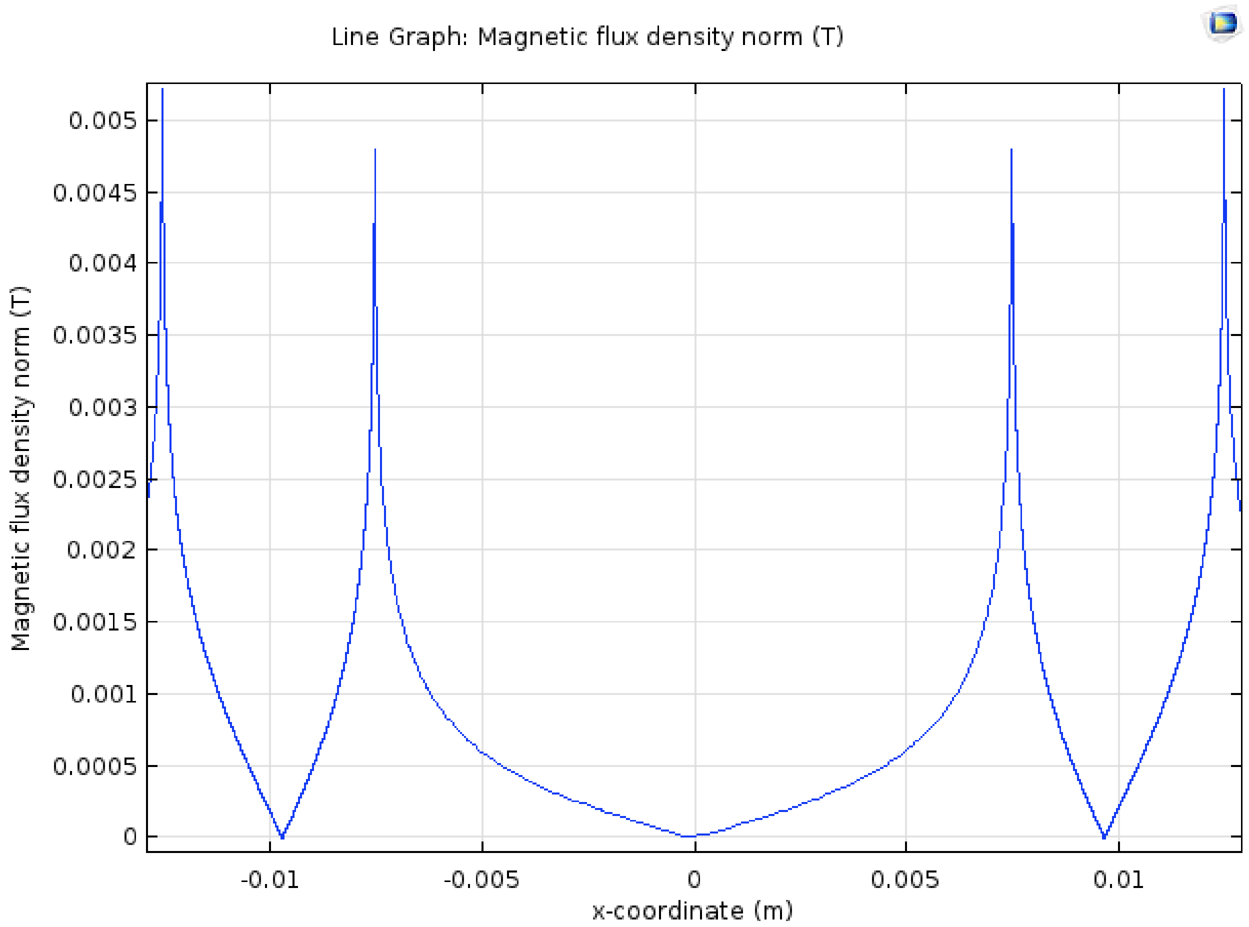
DC:



1 Hz:

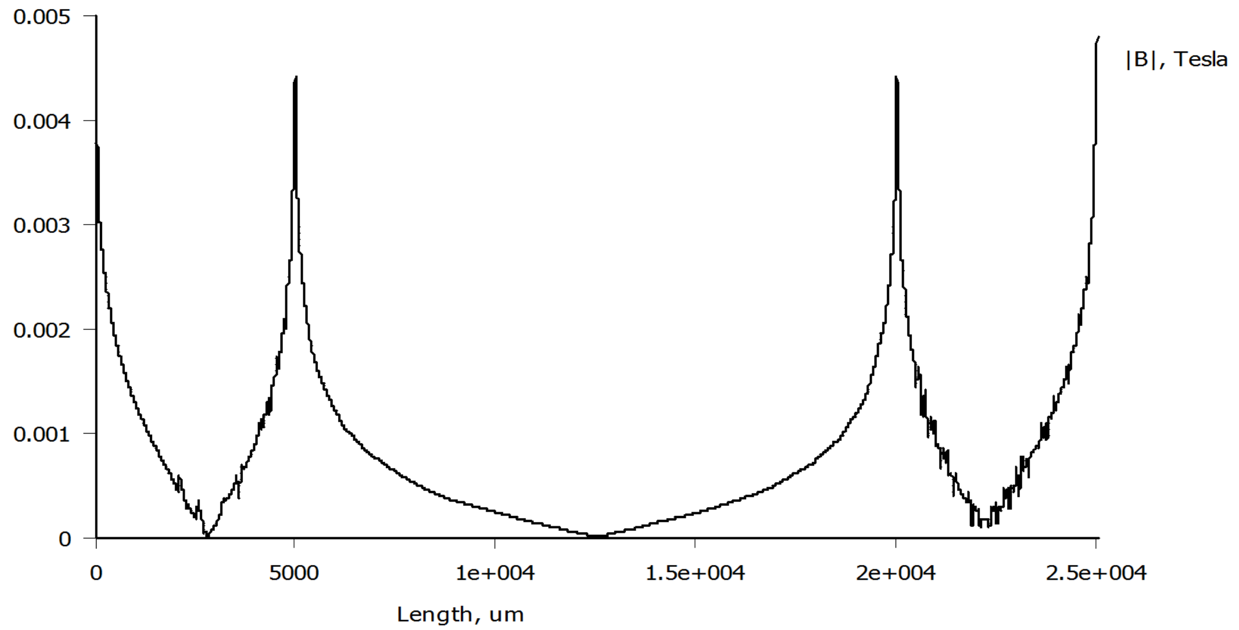


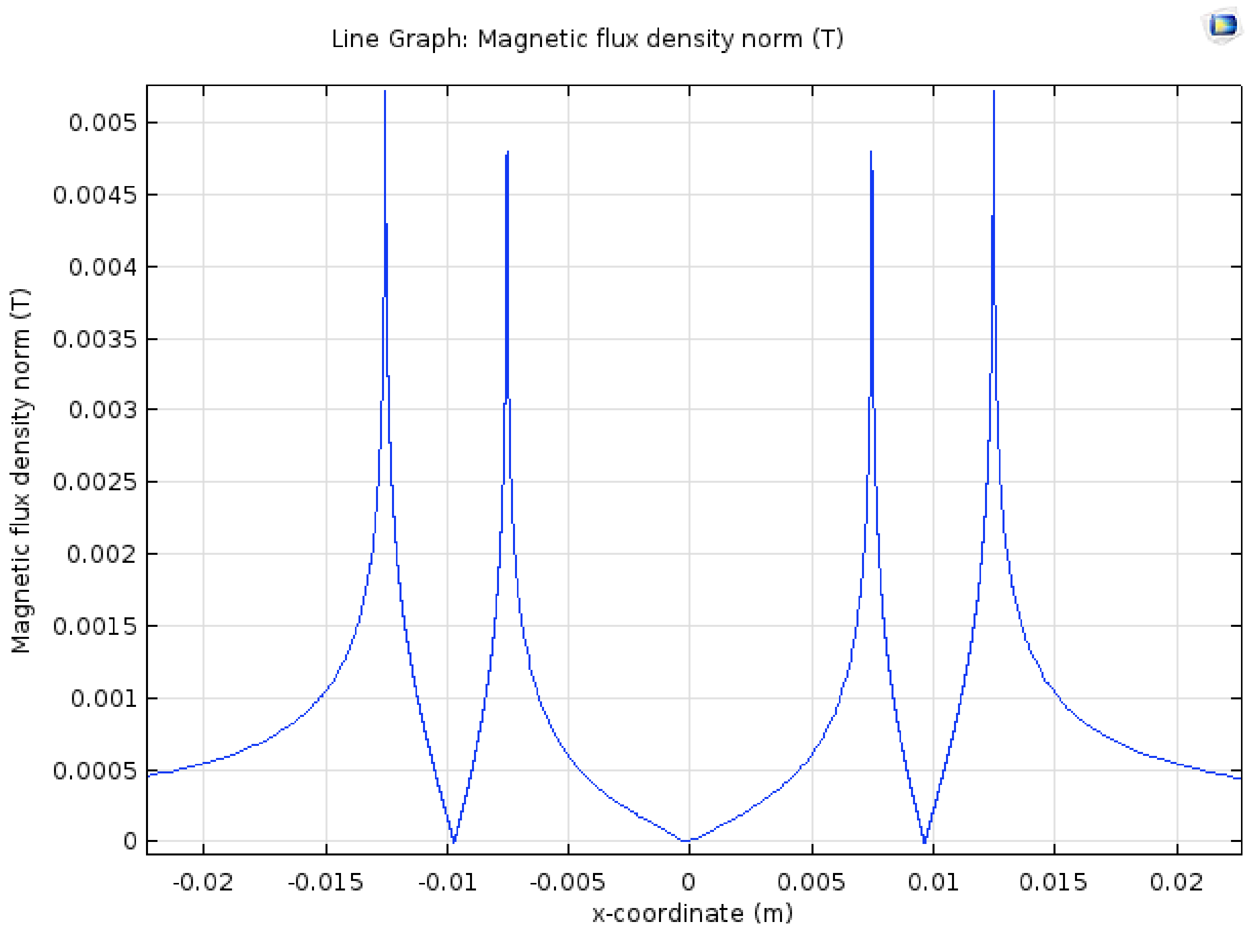
0.005
0.004
0.003
0.002
0.001
0
0
5000
1e+004
1.5e+004
2e+004
2.5e+004
Length, um
|B|, Tesla



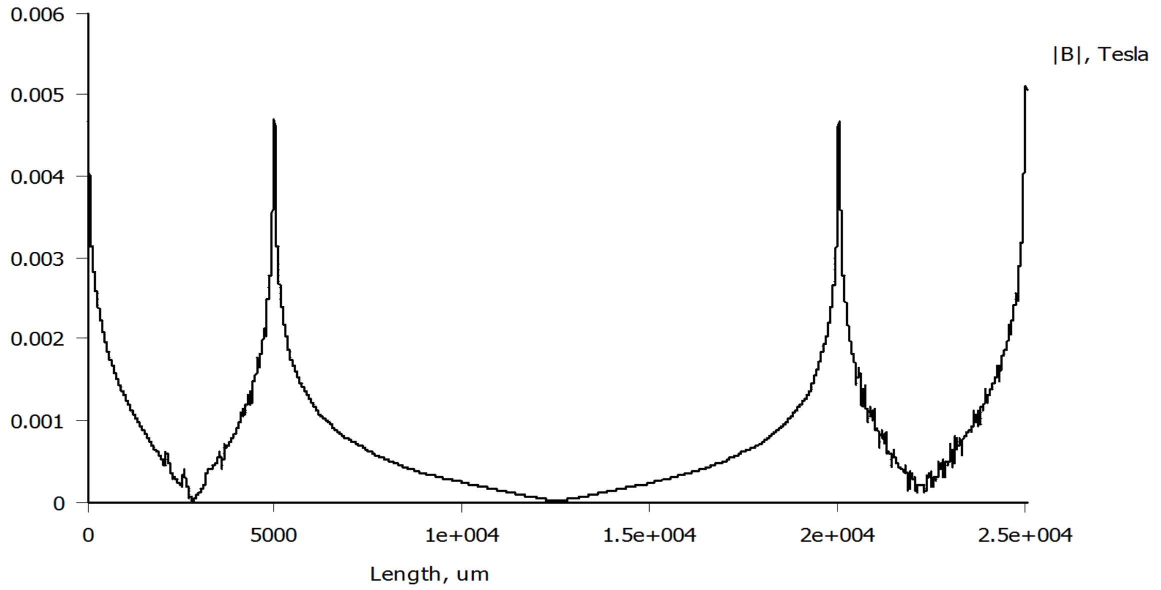
Line Graph: Magnetic flux density norm (T)
Magnetic flux density norm (T)
0.005
0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
-0.01
-0.005
0
0.005
0.01
x-coordinate (m)

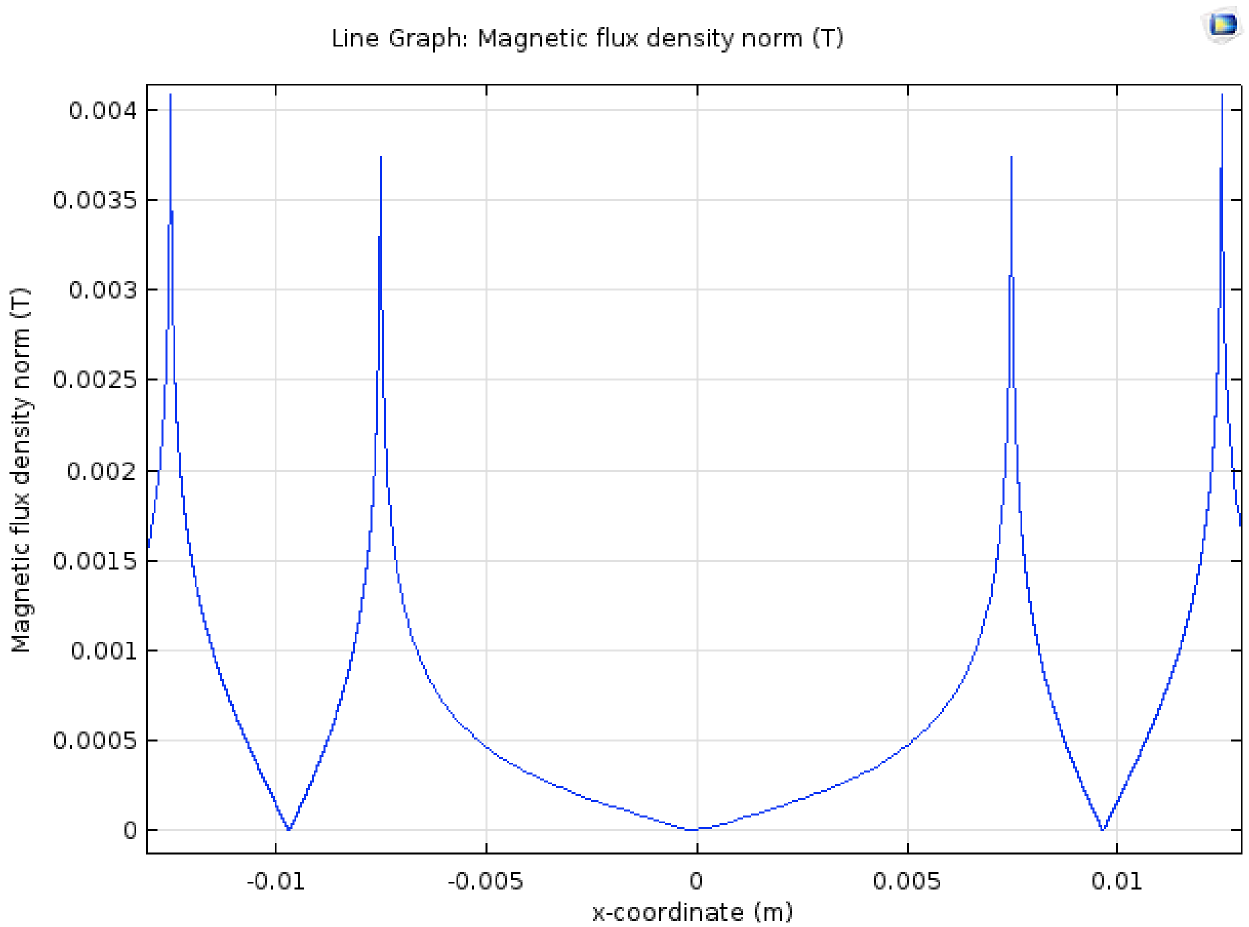
100 Hz:


0.005
0.004
0.003
0.002
0.001
0
|B|, Tesla
0
5000
1e+004
1.5e+004
2e+004
2.5e+004
Length, um

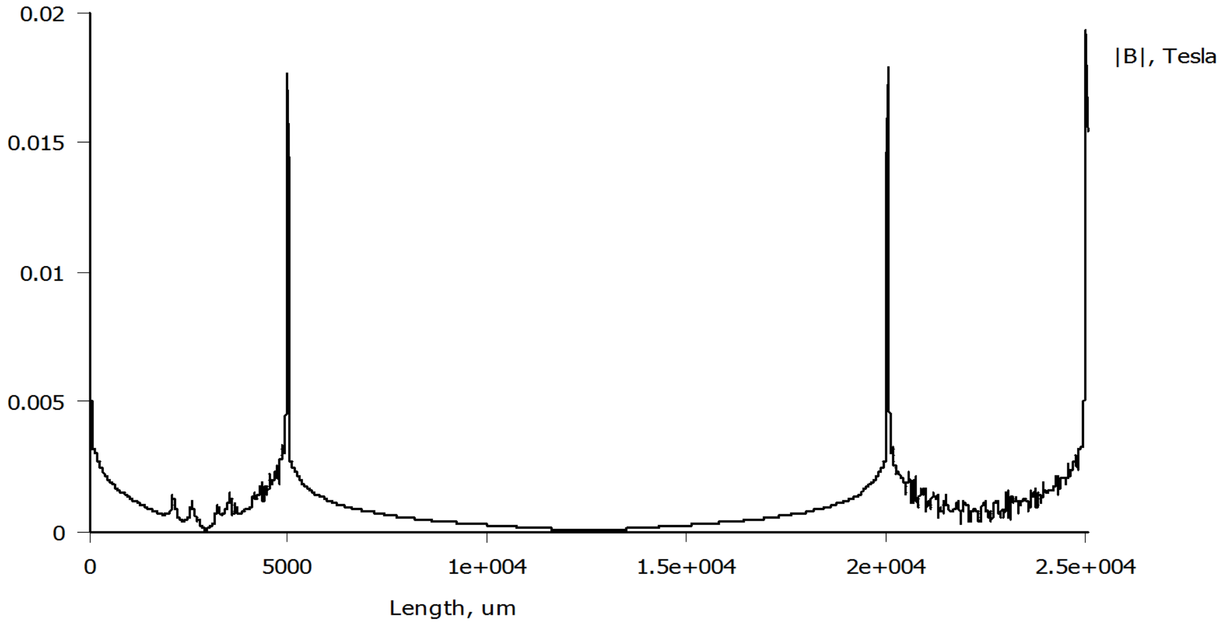

Line Graph: Magnetic flux density norm (T)
Magnetic flux density norm (T)
0.005
0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
-0.02
-0.015
-0.01
-0.005
0
0.005
0.01
0.015
0.02
x-coordinate (m)

10kHz:

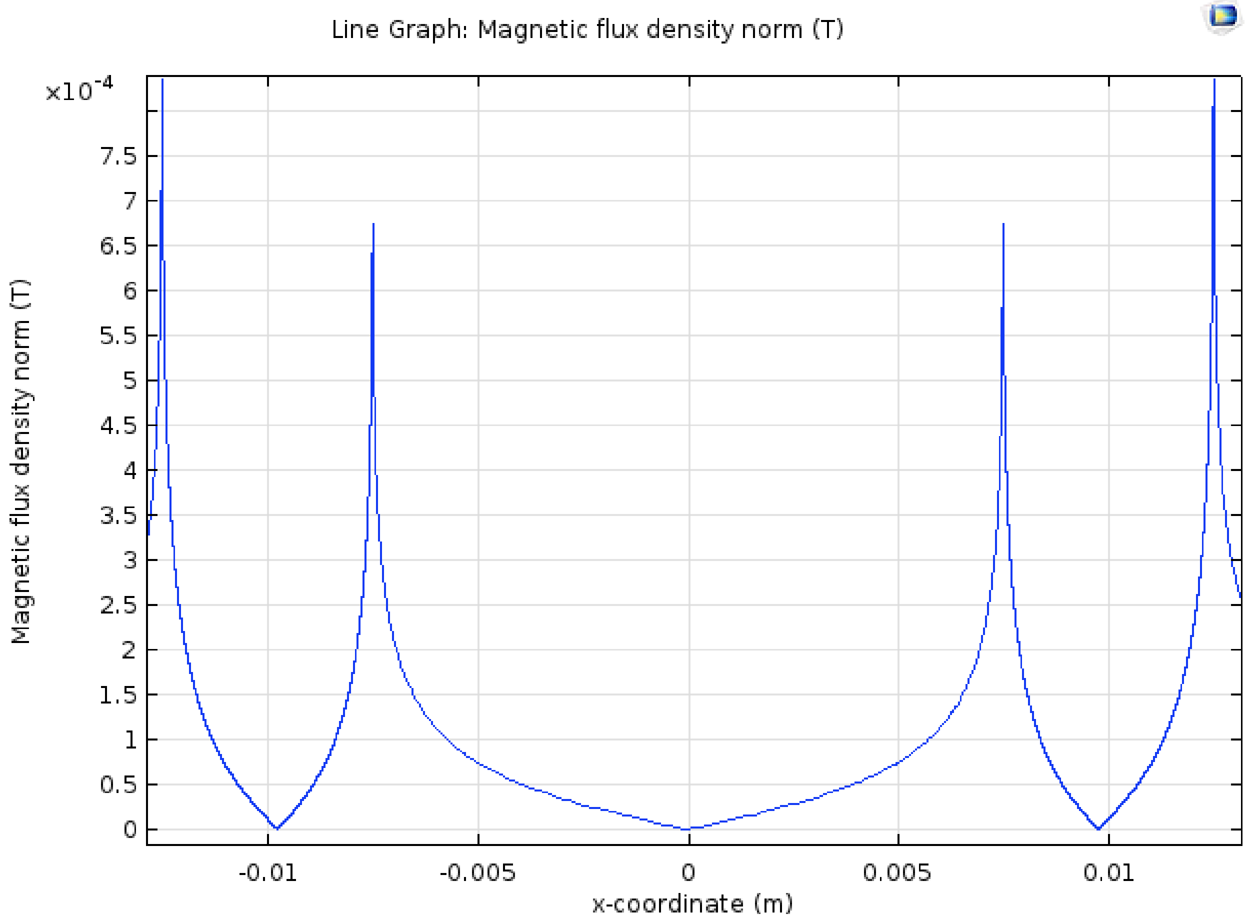

|B|, Tesla
0.006
0.005
0.004
0.003
0.002
0.001
0
0
5000
1e+004
1.5e+004
2e+004
2.5e+004
Length, um


Line Graph: Magnetic flux density norm (T)
Magnetic flux density norm (T)
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
-0.01
-0.005
0
0.005
0.01
x-coordinate (m)

100kHz:

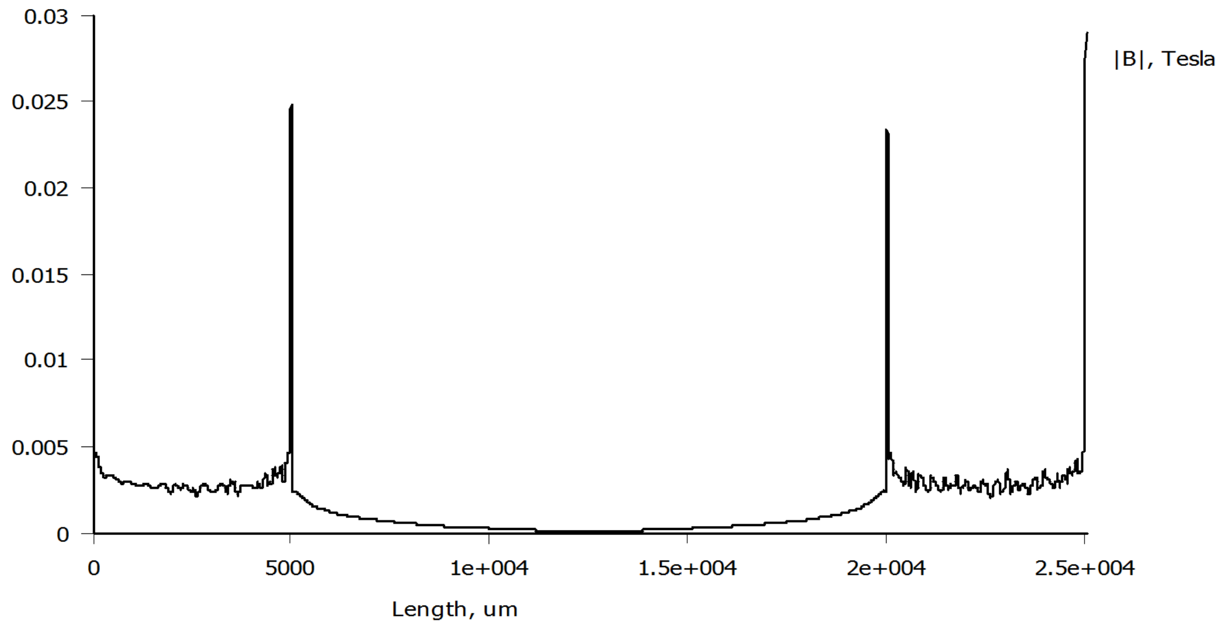


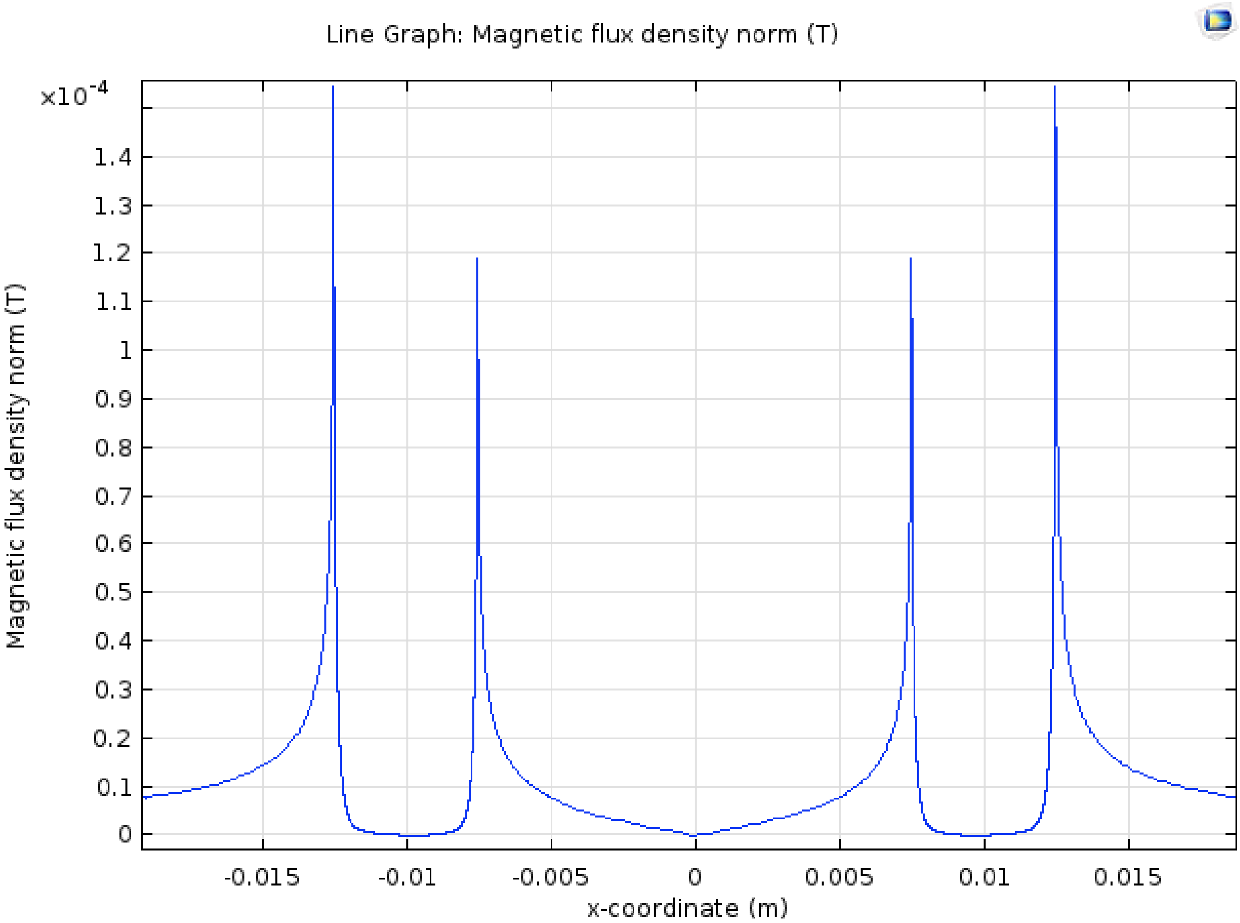
0.02
0.015
0.01
0.005
0
|B|, Tesla
0
5000
1e+004
1.5e+004
2e+004
2.5e+004
Length, um



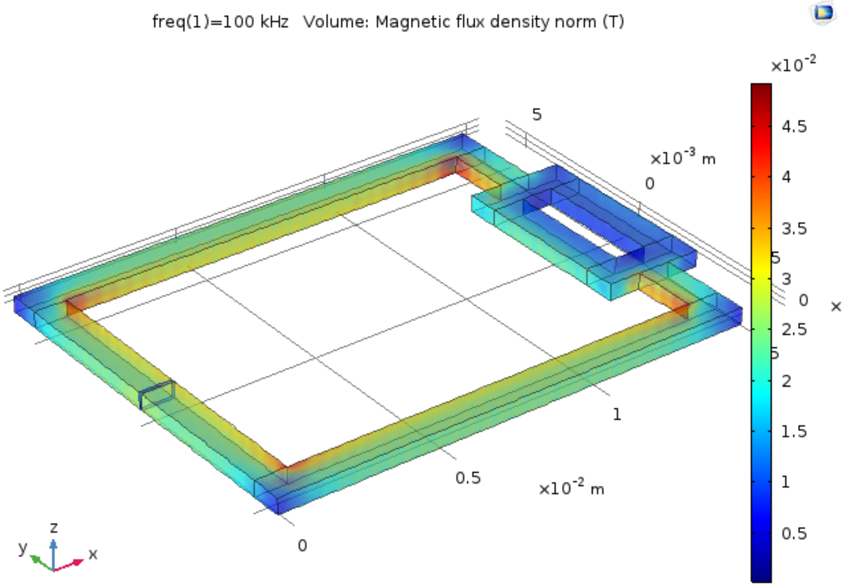
Line Graph: Magnetic flux density norm (T)
×10^-4
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Magnetic flux density norm (T)
-0.01
-0.005
0
0.005
0.01
x-coordinate (m)

1MHz:


0.03
0.025
0.02
0.015
0.01
0.005
0
|B|, Tesla
0
5000
1e+004
1.5e+004
2e+004
2.5e+004
Length, um

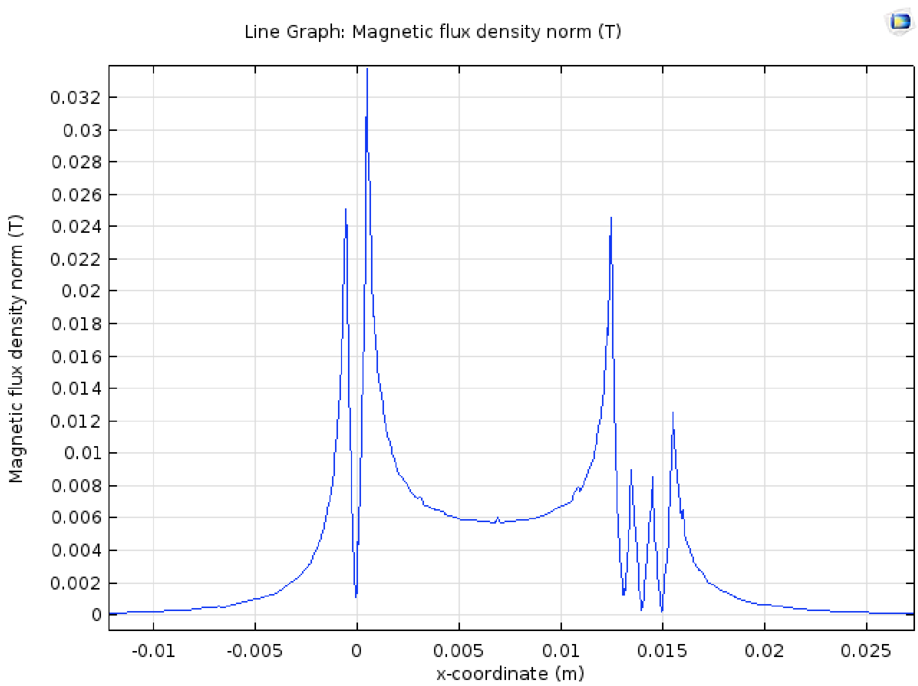

Line Graph: Magnetic flux density norm (T)
×10-4
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Magnetic flux density norm (T)
-0.015
-0.01
-0.005
0
0.005
0.01
0.015
x-coordinate (m)

3D simulation



In this geometry the current distribution at f = 100kHz is shown. The small left rectangle is the Lumped Port that works as input and output of the current. It is obvious that the skin effect already occurs, since the highest current distributions can be found on the inner edges of the traces.

This geometry was designed to simulate the magnetic field of an equal current distribution. Unfortunately, since the current does not flow through the middle of the trace, but along the inner edges, it is not optimally distributed between the two parallel traces on the right. This could be improved by shrinking the dimensions or by shifting the traces, that go into the ones perpendicular to the parallel traces, more to the right.



To understand this diagram that shows the magnetic flux density norm over the x-coordinate you have to imagine a cut through the geometry starting some distance above the Lumped Port and going into the x-direction. So the first two magnetic flux density peaks that are originated around x = 0m can be derived from the current flowing through the Lumped Port.

In between the next peak there is a positive magnetic flux density that comes from the fact that the current through the traces to and from the two parallel traces that matter also result in a magnetic field and these two magnetic fields interfere constructive which can be proven b using the right hand rule.

Another important finding are the **three minimal turning points** in this area that are almost zero despite the unequal distribution of the current. The left and the right of these turning points show the magnetic flux distribution in the middle of the current carrying traces and are neither surprisingly nor important. But the middle turning point is important for the placing of a potential current sensor, because it shows the magnetic flux distribution in between the two current carrying traces.

3D simulation with equal distribution and flat traces

Height: 100um

Frequencies: 250, 500KHz

Current: 20A