

EMC Project I

Extraction of Frequency Dependent Inductance and Resistance

Issue: 2012/03/22

Due: 2012/04/19

Please read the paper entitled “Inductance calculations in a complex integrated circuit environment”, which describes a method for calculating multiloop inductances formed by complicated interconnection conductors, and then solve the following problems.

1. Use the inductance formulas to calculate the partial self and mutual inductances of the two conductors depicted in Fig. 1. Find the loop inductance by the concept of partial inductance. The skin effect is not considered. Simulate the same structure by using the software Q3D, and compare the simulation results with that from the formulas. Comment on these results and validate the correctness of the formulas. [The simplified inductance formulas are also given in Appendix. Please use the simplified formulas as well as the inductance formulas mentioned in the paper for your calculation.]

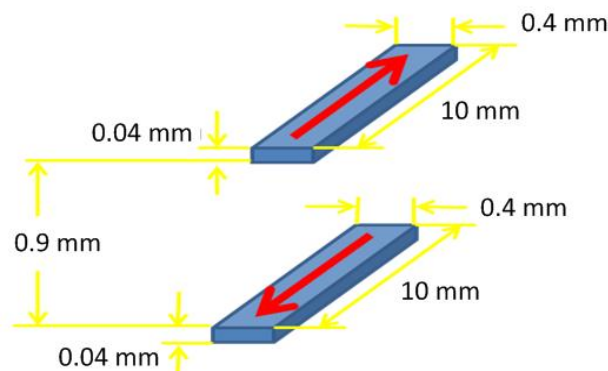


Fig. 1

2. A rectangular bar (copper) is shown in Fig. 2. The size of the bar is also denoted in this figure. Please solve the following problems.
 - (a) Build an equivalent R/L circuit model of the rectangular bar in ADS by dividing it into 3×5 filaments.

- (b) Plot the frequency responses of the effective resistance and inductance from DC to 500 MHz. Comment on your results.
- (c) Plot the current response at filament A and B denoted in Fig. 2 from DC to 500 MHz. The rectangular bar is driven by a 1V AC source.
- (d) Simulate the same structure in Q3D. Discuss the difference between the calculated result and Q3D. Try to explain why.

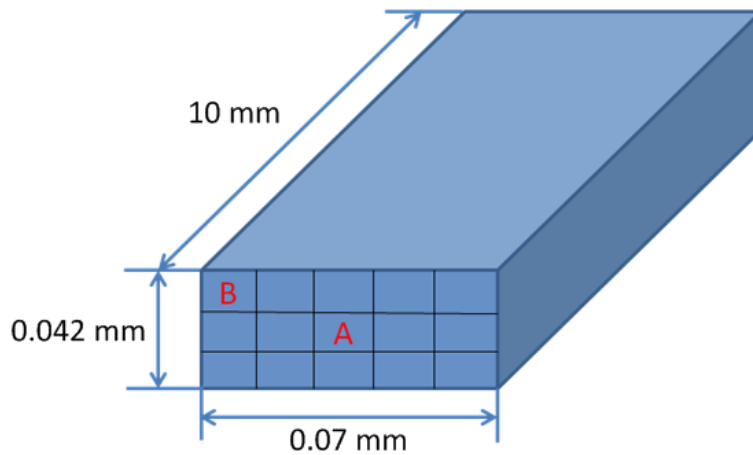


Fig. 2

3. Consider the two strips (copper) shown in Fig. 3. The spacing between them is denoted as d . Solve problems (a)-(c) when the spacing $d = 0.8$ mm. [Note: ignore the skin effect]
 - (a) Partition the two strips into four filaments each and establish the equivalent R/L circuit model of the strips in ADS.
 - (b) Plot the frequency responses of the effective resistance and inductance from DC to 500 MHz and compare them with those obtained from Q3D. Also, please discuss these results.
 - (c) Plot the current distribution on filament A and filament B when the model is excited by a 1V AC source from DC to 500 MHz.
 - (d) Repeat problems (a)-(c) when the spacing is changed to $d = 0.2$ mm. Also, comment on the results with previous problems.

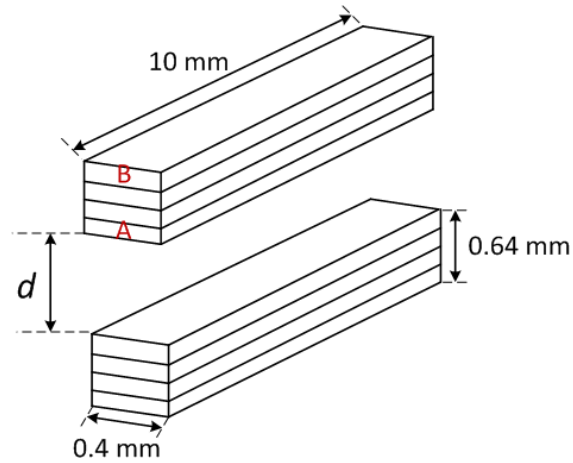


Fig. 3

Appendix

For a metal plate with width W , thickness T , and length l as shown in Fig. 4, the simplified partial self inductance can be written as

$$\frac{L_{ii}}{l_i} = 0.002 \left[\ln \frac{2l}{W+T} + \frac{1}{2} - le \right], \quad (\mu\text{H})$$

where the unit of l_i is in **centimeters**. The parameter le can be found in the following table.

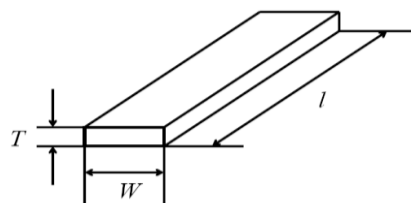


Fig. 4

T/W	le	T/W	le	T/W	le	T/W	le
0	0	0.2	0.00249	0.5	0.00211	0.8	0.00181
0.05	0.00146	0.3	0.00244	0.6	0.00197	0.9	0.00178
0.1	0.0021	0.4	0.00228	0.7	0.00187	1.0	0.00177

The simplified partial mutual inductance of the two lines with the dimensions shown in Fig. 5 can be written as

$$\frac{L_{ij}}{l} = 0.002 \left[\ln \frac{2l}{d} - 1 \right], \quad (\mu\text{H})$$

where the unit of l_i is also in **centimeters**.

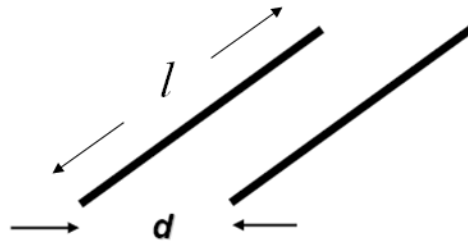


Fig. 5