

## A MATLAB PROGRAM BASED FINITE ELEMENT METHOD FOR COMPUTING AND SIMULATION LORENTZ POWER OF MAGNETIC FIELD

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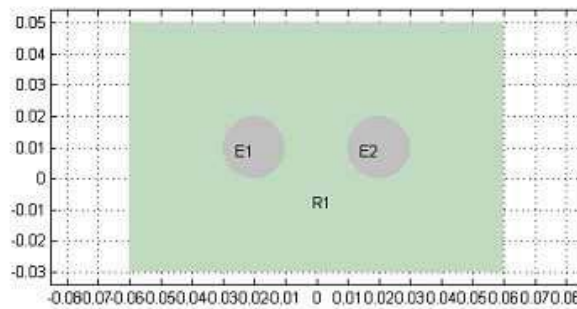
**Abstract** The computation and simulation of the Lorentz force of the magnetic field between two linear conductors of circular section are presented. The model has been constructed in MATLAB, using the finite element method.

**Keywords:** Lorentz power, finite element method, magnetic field.

**2000 MSC:** 78M10, 78A55

### 1. THE REALIZATION OF THE GEOMETRIC MODEL

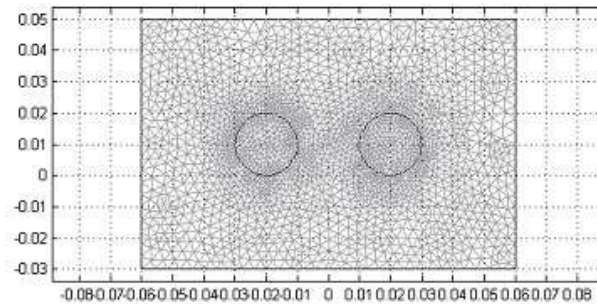
By realizing the geometric model we define the dimensions and the shape of the two conductors and their position in space (fig. 1).



*Fig. 1.* The geometric model definition.

## 2. THE REALIZATION OF THE FINITE ELEMENTS NETWORK

After the geometric elements have been defined, the program automatically splits the studied intervals into finite elements (fig. 2). In this case, we use triangular elements. The parameters of the electromagnetic field are computed in the nodes of the network's elements. To increase the precision of the operations, usually one splits the interval in several finite intervals, realizing a smoother splitting as in fig. 2.



*Fig. 2.* Finite elements network with 2131 nodes.

## 3. MODEL PARAMETERS AND THE MATLAB PROGRAM

The model was realized for alternative (AC) and continuous current (CC); in both cases we realized two models with a 40mm distance between the conductors (AC1, CC1) and 80mm (CA2, CC2). For CC we considered a short-circuit current of  $I = 50000\text{A}$ . For AC the intensity was  $I = 960\text{A}$ . The conductors are supposed to be made out of copper and the medium between the conductors is air.

Part of the MATLAB program that realizes our simulation reads  
Program for computing the Lorentz force.

```
r = 0.01;
Fc=postint(fem,'-2*pi*0.01*0.5*real(Jiz.*conj(Bx))',... 'dl',2);
wt=linspace(0,2*pi,40);
Fv=0.5*real(postint(fem,'-2*pi*0.01*Jiz*Bx','dl',2)*... exp(-2*j*wt));
figure
plot(wt,Fc+Fv,'k')
xlabel('distanta x '),ylabel('forta Lorentz (Fx)')
```

## 4. RESULTS OF SIMULATION

### 4.1. CASE AC1

We can display the results either as electromagnetic field diagram with color codes (fig. 3) or as vectorial diagram (fig. 4).

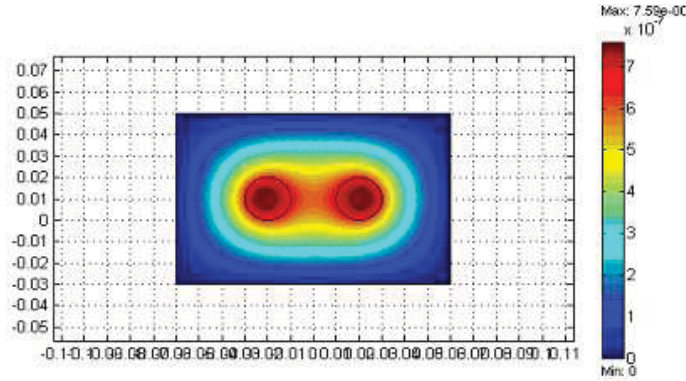


Fig. 3. Electromagnetic field diagram with color codes.

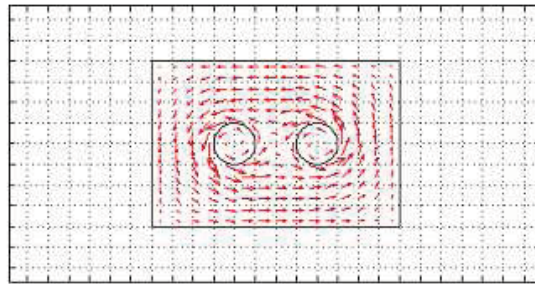
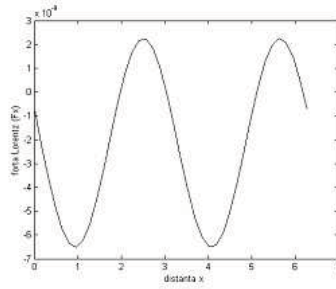


Fig. 4. Diagram for the vectorial representation of the electromagnetic field.

In order to compute the Lorentz force we need an additional program (Annex "Program for computing the Lorentz force"). This program computes the Lorentz force and displays the diagram presented in fig. 5.

After computing the Lorentz force we model the conductor under the influence of Lorentz forces. We consider two distinct cases:

- cantilever conductor at one end for a charge value that corresponds to a 40mm distance between conductors (fig. 6) and 80mm (fig. 7);
- cantilever conductor at two ends for a charge value that corresponds to a 40mm distance between conductors (fig. 8) and 80mm (fig. 9).

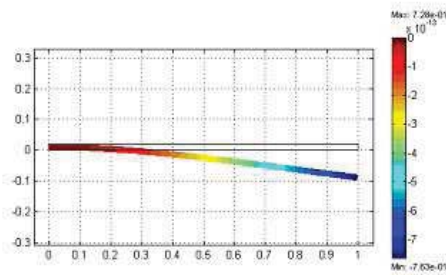


*Fig. 5.* Lorentz force diagram for AC1.

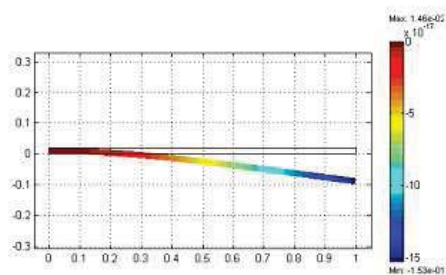
The modeling was made assuming that the Lorentz force acts as an impulse (short-circuit state) with amplitude computed previously. The model simulates the response in frequency of the conductor at this impulse.

The maximum values for the displacement are:

- cantilever conductor at one end, distance 40mm: maximum displacement =  $-7,5 \cdot 10^{-13}$ ;
- cantilever conductor at one end, distance 80mm: maximum displacement =  $-1,5 \cdot 10^{-15}$ ;



*Fig. 6.* Cantilever conductor at one end, distance 40 mm.



*Fig. 7.* Cantilever conductor at one end, distance 80 mm.

- cantilever conductor at two ends, distance 40mm: maximum displacement =  $-1,5 \cdot 10^{-14}$ ;
- cantilever conductor at two ends, distance 80mm: maximum displacement =  $-3,2 \cdot 10^{-18}$ ;

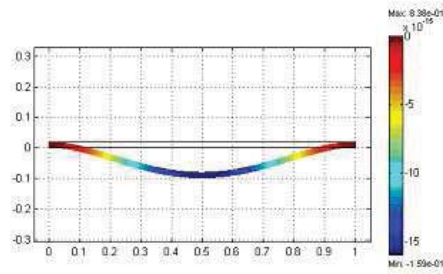


Fig. 8. Cantilever conductor at two ends, distance 40 mm.

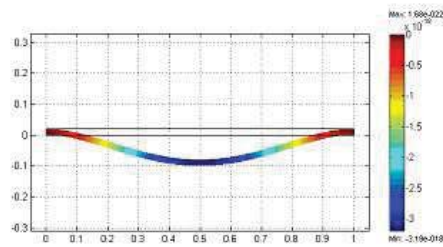


Fig. 9. Cantilever conductor at two ends, distance 80 mm.

## 4.2. RESULTS OF THE SIMULATION FOR AC2

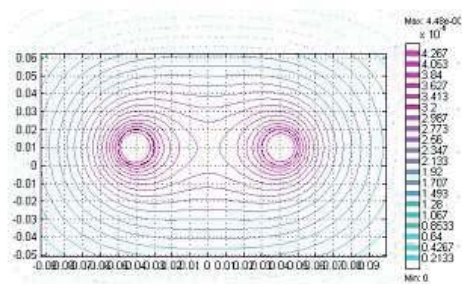
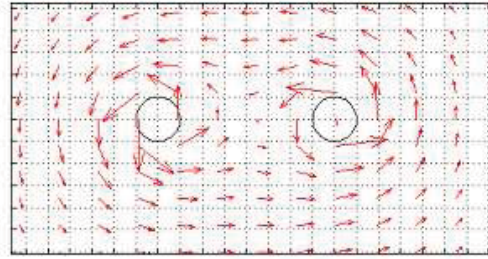
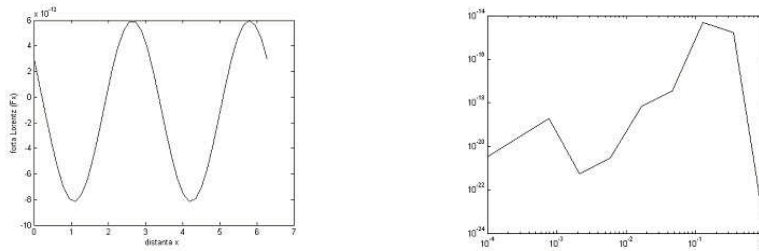


Fig. 10. Field lines diagram.

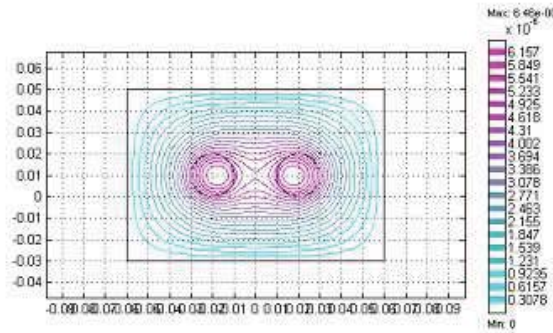


*Fig. 11.* Vectorial diagram.



*Fig. 12.* Lorentz force diagram.

### 4.3. RESULTS OF THE SIMULATION FOR CC1 AND CC2



*Fig. 13.* Field lines diagram.

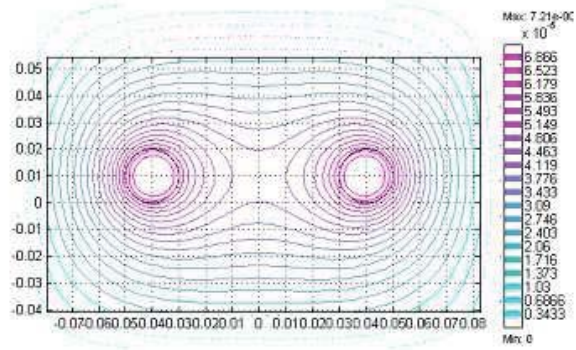


Fig. 14. Field lines diagram.

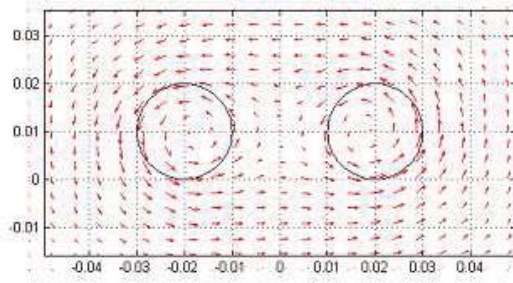


Fig. 15. Vectorial diagram.

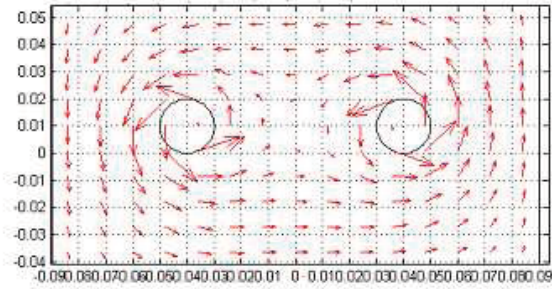
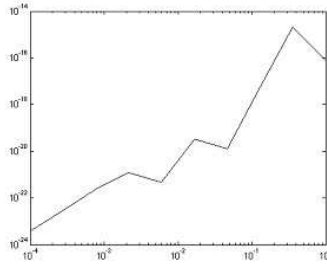


Fig. 16. Vectorial diagram.



*Fig. 17.* Lorentz force diagram.

## 5. CONCLUSIONS

From the results of the simulations we conclude the following:

- the smaller the distance between the conductors, the bigger the forces;
- it is recommended to lean the bar system at two ends, because a simply cantilever bars system is more solicited;
- the distances between the insulators that sustain the bars have to be chosen so that the stress and deformation be minimum;
- under the action of electro-dynamics forces the bars may bend, so that they may diminish the insulation between the phases;
- the leaned bar system rezemat presents much bigger deformations than the cantilever bar system;
- the installations have to resist to the electro-dynamic forces produced by the shock current and it is not necessary to withstand the short-circuit currents permanently.

## References

- [1] Bathe, K. J., *Finite element procedures in engineering analysis*, Prentice Hall, Englewood Cliffs, NJ, 1982.
- [2] Vasilievici, A., Andea, P., *Apparata and electric equipments*, Orizonturi Universitare, Timisoara, 2004. (Romanian)