

Assignment 2: Computation of the electric field in a coaxial cable

1. Objective of the assignment

The aim of the assignment is to solve an electrostatic problem with different permittivity using a numerical tool called FEMM. The learning objective is to be able to apply knowledge from the literature to solve real life problems and to be acquainted with the freely available software tools.

2. Theory

The electrical field in a coaxial cable can be solved analytically using the equations presented in the lectures:

$$E = \frac{U}{r \log\left(\frac{r_i}{r_o}\right)}$$

Where E is the electric field, U the potential difference between the inner and outer conductors of the cable, and r_i r_o are the inner and outer radius of the conductors. However, if the permittivity in the region between the inner and outer conductor is not constant, the problem became more complex. The electric field, in this case, can be computed with the finite element method, which a numerical method to solve different kinds of differential equations. The problem parameters are sketched in Fig 1., where the length of the cable is now assumed infinite.

In this assignment, we will solve the above problem with a finite element software called FEMM. The software can model several physical problems in 2D approach, in either a static or a time harmonic analysis. The objective is to find out the electric field distribution in the cross section of the cable.

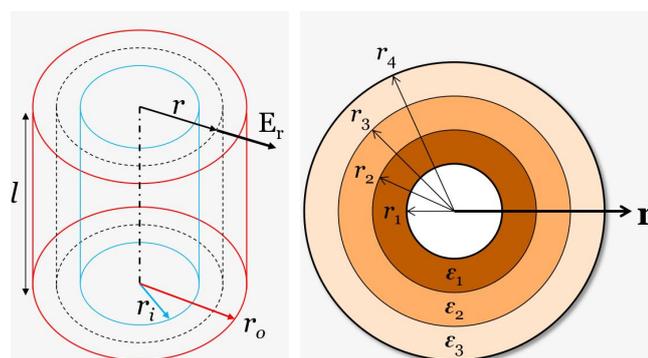


Fig. 1: geometry of the cable.

3. Tasks

The specific tasks are as follows:

1. Download and install FEMM on your personal computer, choose the version that fits your computer (32 or 64 bits)

<http://www.femm.info/wiki/download>

2. Draw the geometry of the cross section of the cable, set the material properties, the boundary conditions and the source potentials. See how to do this in the video at the end of this document. You might need to have a look at the software manual too. Note that in this assignment, the outer conductor has a thickness, which is not seen in Fig.1.
3. Make a mesh and solve the problem in a static case
4. Plot the electric field along a radial line from the center of the cable to the outer boundary limit.
5. Check the value of the maximum electric field against the breakdown field of air (3 kV/mm).
6. Comment on the validity of the solution obtained.
7. Make a report of the assignment and submit it to MyCourse, under assignment 2 return box.

Table 1: Model parameters

Parameter	Value
r1	10 mm (inner conductor)
r2	40 mm, permittivity $1,5 \cdot \epsilon_0$
r3	80 mm, permittivity $2 \cdot \epsilon_0$
r4	150 mm, permittivity $4 \cdot \epsilon_0$
r5	155 mm (outer conductor)
U _{in}	100 kV (inner conductor voltage)
U _{out}	0 V (outer conductor grounded)

For a quick introduction to FEMM software, you might have a look at this video:

<https://www.youtube.com/watch?v=2vpicUAD3us>