Exercise 1

Question

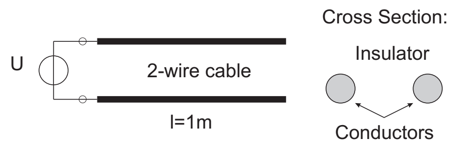

Abbildung 1: 2-wire cable setup and cross section of 2-wire cable.

A 1 m long piece of 2-wire cable is depicted in fig. 1. At one end of the cable a constant voltage source is attached whereas the other end is open. The wires of the cable are assumed to be ideally conducting while the medium between the wires is an ideal insulator.

1. Will there be an electric field, a magnetic field or both in between the wires?
2. Which of Maxwell's equations govern this field?
3. Which material equation is involved?
4. What are the boundary conditions of this field?
5. How can the in 2) selected set of equations be simplified?
6. Do the boundary conditions correspond to Dirichlet or Neuman boundaries, if you look at the associated potential?
7. Where in the cross section of the cable do you expect the highest field strength.

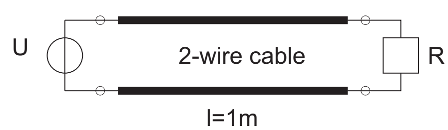

Abbildung 2: 2-wire cable setup terminated with resistor.

Now the second end of the cable is terminated with a resistor R.

1. Compute the current in one wire.
2. Will there be an electric field, a magnetic field or both in between the wires?
3. Which of Maxwells equations govern these fields?
4. Which material equation is involved?
5. What are the boundary conditions of these fields?

Solution

Answers for the open case:

1. There will be only an electric field as there are no currents.
2. $div\vec{D} = \rho$ and $rot\vec{E} = 0$.
3. $\vec{D} = \epsilon\vec{E}$.
4. Tangential electric field must be zero and normal electric field is different from zero.
5. The electrostatic potential φ can be used instead of the electric field. By setting $grad\varphi = \vec{E}$, one fulfills $rot\vec{E} = 0$ automatically. $div\vec{D} = \rho$ and $\vec{D} = \epsilon\vec{E}$ yield with this definition of the potential $\triangle\varphi = \frac{\rho}{\epsilon}$.
6. The associated potential problem has Dirichlet boundaries.
7. The highest electric field strength is expected on the crossing points of the shortest line which connects both conductors and the surface of the conductors.

Answers for the terminated case:

1. The current will be $I = \frac{U}{R}$.
2. There will be an electric field and a magnetic field.
3. The electric field is governed by $div\vec{D} = \rho$ and $rot\vec{E} = 0$. The magnetic field is governed by $div\vec{B} = 0$ and $rot\vec{B} = \vec{J}$.
4. $\vec{D} = \epsilon\vec{E}$ and $\vec{B} = \mu\vec{H}$.
5. Tangential electric field must be zero and normal electric field is different from zero. The tangential magnetic field is different from zero and the normal magnetic field is equal to zero.