Electronics Lab Course
Experiment #1: Expansion of signals in conducters

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Contents

1 Theoretical background

1.1 Conducting properties

If the electrical properties of a double-cable are equal on the whole cable, it is called homogeneous. In this experiment, we work with such cables.
Capacitive and inductive properties of the cable are:

$$\begin{aligned} C &= \epsilon_r \epsilon_0 l \frac{2\pi}{\ln\left(\frac{r_a}{r_i}\right)} \\ L &= \mu_r \mu_0 \frac{\ln\left(\frac{r_a}{r_i}\right)}{2\pi} \end{aligned}$$

The four characteristics of a cable[1] grow proportional to it's length. A lossless cable can be approximated as a chain of many LC-links.

1.2 Expansion of waves in homogeneous cables

$$\begin{aligned} \frac{d^2}{dx^2}U - \gamma^2 U &= 0 \\ \gamma^2 &= z' \cdot y' \Rightarrow \text{damping} \\ \textit{solution}: \quad U(x,t) &= U_f(x,t) + U_b(x,t) \quad \text{f: forward, b: backwards} \\ I(x,t) &= I_f(x,t) + I_b(x,t) \end{aligned}$$

1.3 Phase velocity and wave resistance

The phase velocity is:

$$v_{Ph} = \frac{c_0}{\sqrt{\epsilon_r \mu_r}}$$

It is equal to the velocity of waves with equal wavelength in matter with equal ϵ_r and μ_r.
In lossless case the wave resistance is:

$$\begin{aligned} z &= \sqrt{\frac{L'}{C'}} \\ &= \sqrt{\frac{\mu_r \mu_0}{\epsilon_r \epsilon_0}} \cdot \frac{\ln\left(\frac{r_a}{r_i}\right)}{2\pi} \end{aligned}$$

[1] Resistance, inductance, capacity and loss

adjusted termination terminal resistance = wave resistance

1.4 Cable termination and adjustment

Inside a cable there is not only the incoming, but also a reversal wave of voltage or current.
But depending on the termination it can be absorbed.

2 Preperational exercises

3 Experiment set-up

4 Procedure

5 Measurement

6 Evaluation

7 Conclusion