Introduction to Electrical and Electronic Circuits

LAB. 6

Transmission line

Problems:

1. When a circuit has to be regarded as a circuit with distributed parameters i.e. as a transmission line?
2. When the transmission line is called:
   - a loosless line
   - a distortionless line

   (Explain the differences between voltage and current waveforms in these lines)
3. How can:
   - characteristic impedance Z
   - propagation velocity v
   - attenuation constant

   be experimentally measured?
4. When the line is matched at the input and at the output?
5. Assume a loosless transmission line as shown in fig. 1. Draw u(t,0), i(t,0), u(t,l/2), i(t,l/2), u(t,l), i(t,l), $u(t_o/2, x)$, $i(t_o/2, x)$, $u(3t_o/2, x)$, $i(3t_o/2, x)$, $u(5t_o/2, x)$, $i(5t_o/2, x)$ where t_o=l/v for every combination of the generator waveform e(t), generator impedance Z_1 and load impedance Z_2 from the following:
   - e(t)
     1. constant source E switched on at t=0; e(t)=E1(t)
     2. a rectangular pulse of width $t_o/4$, $t_o/2$, t_o, $3t_o/2$, $2t_o$
     3. a symmetrical triangle of width $t_o/4$, $t_o/2$, t_o, $3t_o/2$, $2t_o$
   - Z_1=0; Z/5; Z; 4Z
   - Z_2=0 (short circuit); Z/5; Z (load match); 4Z; open circuit; a capacitor C; an inductor L; a serial/parallel connection of a capacitor/inductor and a resistor R=Z.
   -

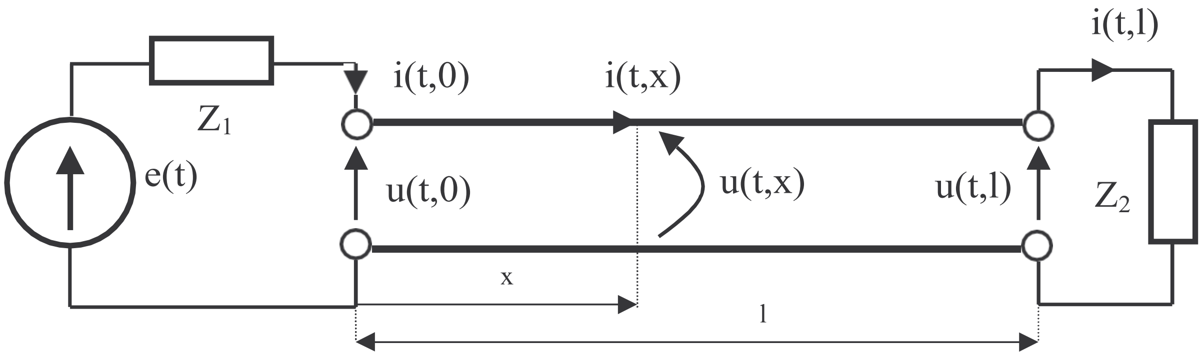

Fig. 1

Programme

Set the generator frequency f_{gen}=1 MHz. Make sure the pulses are symmetrical i.e. a duty factor is 1/2. Assembly a circuit shown in fig. 2. The set of plugs enables you to load the line with a number of different loads and to have a set of different input impedance values.

Generators used in this lab have an internal impedance Z_{gen}=50Ω. To increase the input impedance over 50 Ω you have to add some serial impedance Z_a. To decrease the input impedance below 50Ω you have to add some parallel impedance Z_b. A plug denoted with a single Ωgure may be used for Z_l and Z_a while the only plug denoted with two Ωgures (0/50Ω) is to be used for both Z_a and Z_b (0/50Ω meaning Z_a=0Ω and Z_b=50Ω).

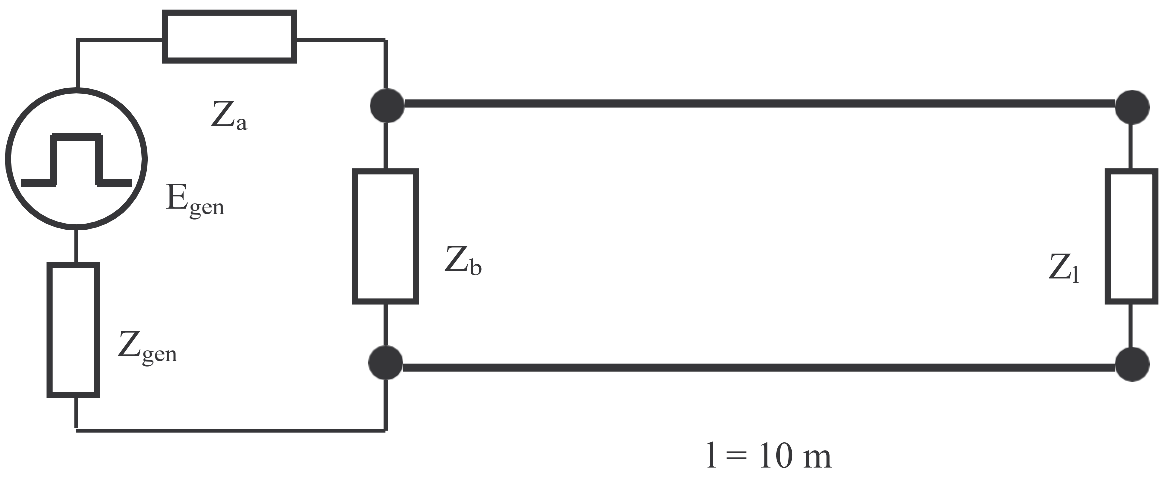

Fig. 2

1. Taking into account that line length l=10 m measure Z and v.
2. Observe voltages at line input and output for the following input and load impedances:
   a). Z_a=25Ω, Z_l=∞ (line open)
   b). Z_a=25Ω, Z_l=250Ω
   c). Z_a=25Ω, Z_l=0 (short circuit at the output)
   d). Z_a=25Ω, Z_l = 1/SC (line loaded with a capacitor C = 1.5 nF)
   e). Z_a=0, Z_b=50Ω, Z_l=∞ (line open)
   f). Z_a=0, Z_b=50Ω, Z_l=0 (short circuit at the output)
   g). Z_a=0, Z_b=50Ω, Z_l=75Ω
   h). Z_a=250Ω, Z_l=∞ (line open)
   i). Z_a=250Ω, Z_l=0 (short circuit at the output)
   j). Z_a=250Ω, Z_l=75Ω
3. Check influence of oscilloscope cables and non-ideal pulse on observed waveforms.
4. Set Z_a=0, Z_b=50 Ω, Z_l=∞ (line open) and f_{gen} so that pulse period equals 4l/v (or equivalently pulse width equal 2l/v). Observe input and output voltages. (Set the trigger mode of the oscilloscope to the channel 2).

Report

1. Calculate v. Based on this estimate line primary parameters L and C (assume lossless line).
2. Draw observed waveforms (see items 2 and 4 in the "Programme" section) and compare them with theoretical calculations (also included and considered in the report).
3. Comment on item 3 in the "Programme" section.
4. Explain the waveforms observed at item 4.