Lab number: 4

Lab title: Normal incidence of TEM wave onto layered media

Date lab was performed: 18.05.2020

Names of lab group members: Krzysztof Rudnicki

Theoretical introduction:

We are going to investigate on the transmission of TEM wave which goes through the layered media and finding some practical applications. Laboratory consists of two parts:

Firstly we will concentrate on the transmission through a dielectric slab surrounded with the air. This will help us understand the phenomenon of non reflecting full-wave slab and familiarize with the half-wavelength transformer.

Secondly we will work on more complex scenario where there are three different dielectrics and we will try to make a design of the matched quarter-wave transformer.

a = 8,5

Cases:

$$\varepsilon_r = 8{,}5, f_1 = 6{,}86 \text{ GHz}$$

1) Dielectric slab in the air. Diel medium is a lossless non-magnetic dielectric. We need to find in each case:
   SWR_1, λ_1 in the first region
   SWR_2, λ_2 in the second region
   SWR_3, λ_3 in the third region

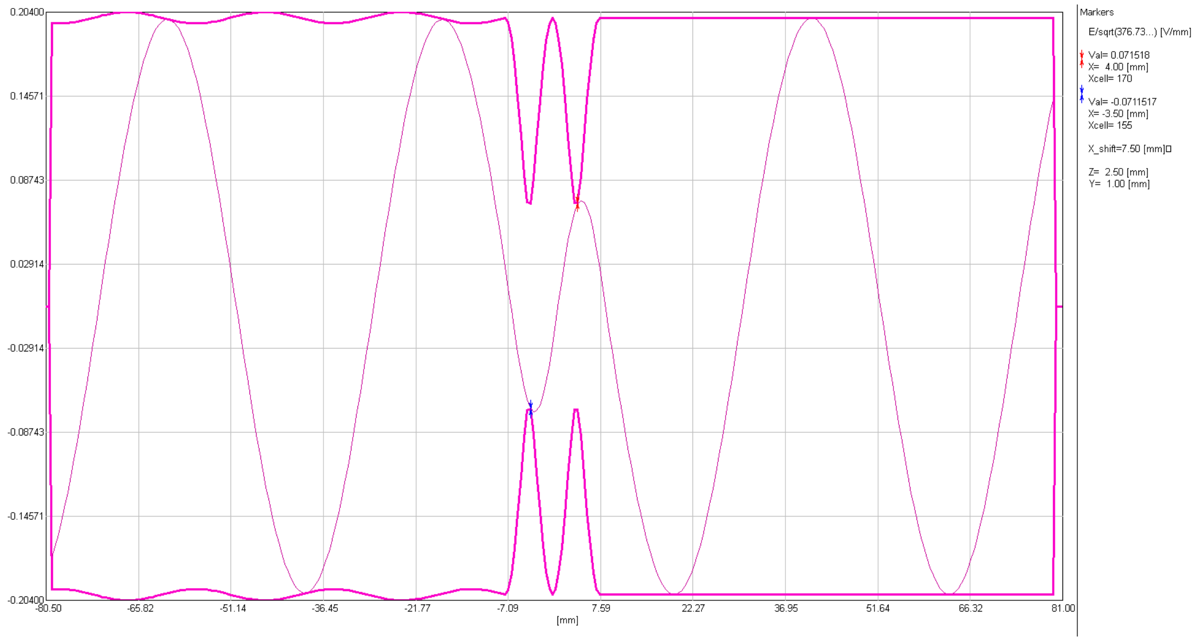
   For

$$f_1, 0{,}5f_1, 0{,}9\, f_2$$

2) $\varepsilon_r = 8{,}5, f_1 = 2{,}93 \text{ GHz}$
   Dielectric slab between the air and another dielectric. Diel medium is a lossless non-magnetic dielectric. We need to find:
   SWR_1, λ_1 in the first region
   SWR_2, λ_2 in the second region
   SWR_3, λ_3 in the third region

1) $f_1 = \frac{c}{\sqrt{\varepsilon_2 \times d}} = 6{,}86\ \text{GHz}$

Where c – light speed, ε_2 is equal to a and d is slab length.

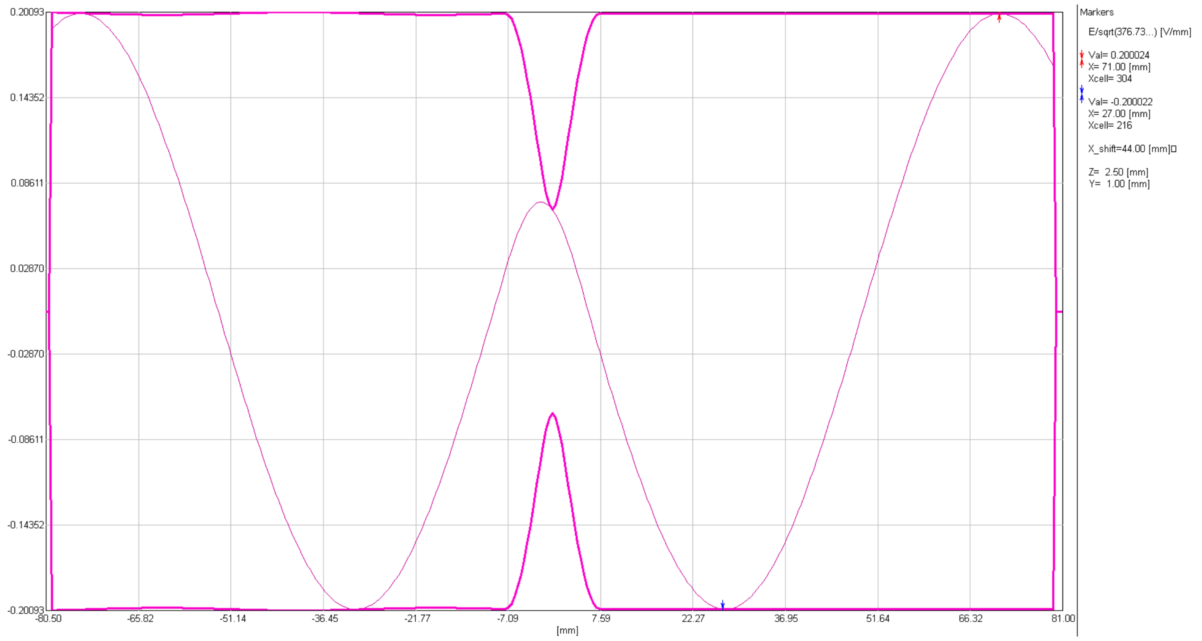


$$SWR_1 \approx 1, \lambda_1 = 43\ \text{mm}$$

$$SWR_2 \approx 2{,}8, \lambda_2 = 30\ mm$$

$$SWR_3 \approx 1, \lambda_3 = 43{,}5\ \text{mm}$$

$0{,}5 \times f_1 = 3{,}43\ \text{GHz}$

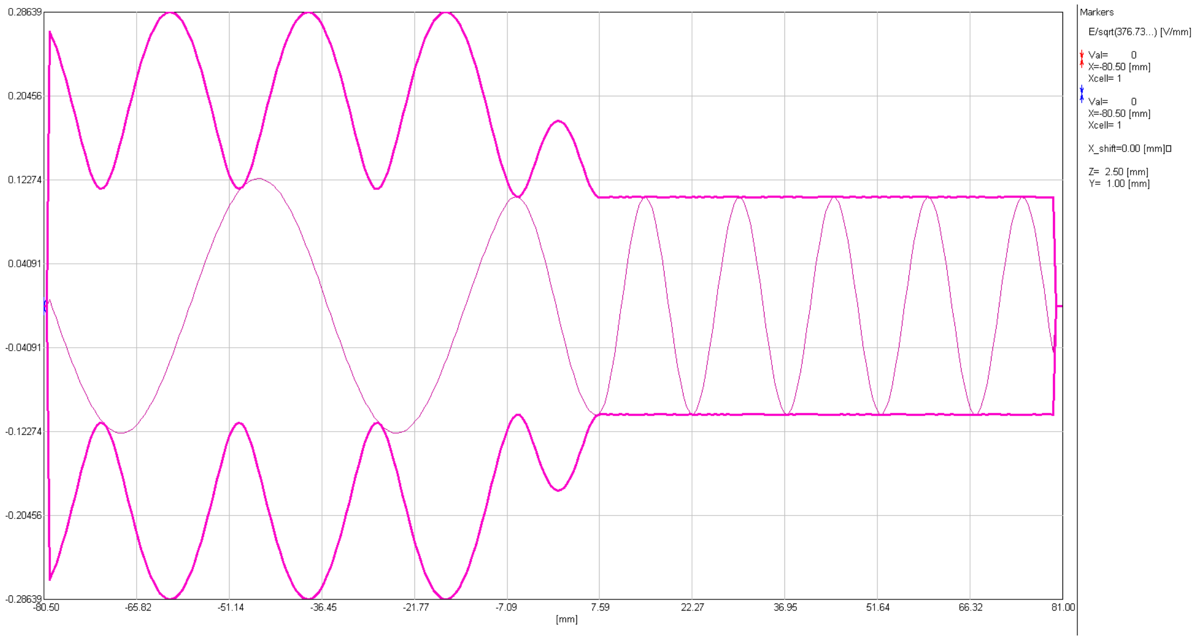


$$SWR_1 \approx 1, \lambda_1 = 88\ \text{mm}$$

$$SWR_2 \approx 2{,}9, \lambda_2 = 28\ mm$$

$$\mathrm{SWR}_3 \approx 1, \lambda_3 = 88\ \mathrm{mm}$$

$0{,}9\ \times \mathrm{f}_1 = 6{,}18\ \mathrm{GHz}$



$$\mathrm{SWR}_1 \approx 3{,}9, \lambda_1 = 48\ \mathrm{mm}$$

$$\mathrm{SWR}_2 \approx 2{,}8, \lambda_2 = 18\ mm$$

$$\mathrm{SWR}_3 \approx 1, \lambda_3 = 48\ \mathrm{mm}$$

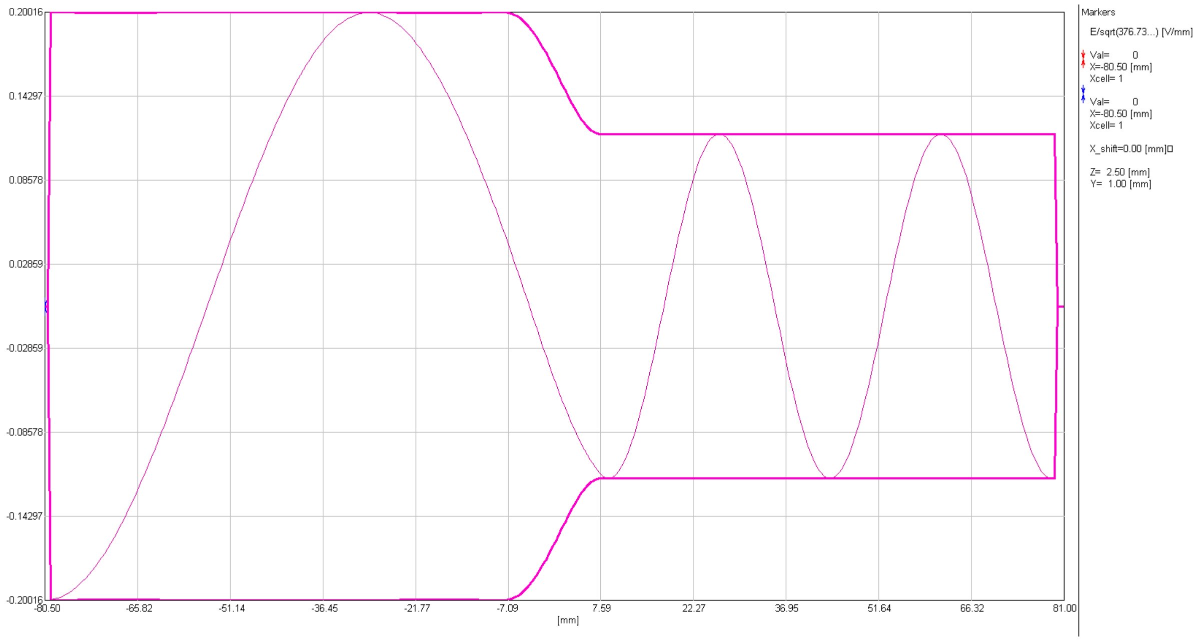
How do the envelopes look like at each frequency?
See screens above

Describe your understanding of a half-wave transformer:
When we use it for EM wave, it is transparent.

How does it transform the impedance of the third medium?
Half-wave transformer does not transform the third medium at all.

2) $\mathrm{f}_1 = \frac{\mathrm{c}}{4\times\sqrt{\varepsilon_2}\times \mathrm{d}} = 6{,}86\ \mathrm{GHz},$

$\varepsilon_{\mathrm{diel\_1}} = \sqrt{\mathrm{a}} = 2{,}91$ and $\varepsilon_{\mathrm{diel\_2}} = 8{,}5$



$$\mathrm{SWR}_1 \approx 1, \lambda_1 = 102 \text{ mm}$$

$$\mathrm{SWR}_2 \approx 1{,}7, \lambda_2 = 56\, mm$$

$$\mathrm{SWR}_3 \approx 1, \lambda_3 = 34 \text{ mm}$$

How do the envelopes look like in the intermediate slab?
They look like sinus wave, as shown in the picture above.

Describe your understanding of a quarter-wave transformer.
What it does is inverting the impedance.

How does it transform the impedance of the third medium?
First impedance is equal to 3 times the impedance of the third medium.

Answer the following questions:

a) What is the impedance condition for the quarter-wave transformer?

$$Z_2 = \sqrt{Z_1 \times Z_3}$$

b) Propose the possible applications of a half-wave transformer:
We can use it either for signal demodulation circuit. Circuits which are going to generate pulses or battery charger circuit for low power.