Lab number: 6

Lab title: Modes in rectangular waveguide

Date lab was performed: 04.06.2020

Names of lab group members: Krzysztof Rudnicki

Theoretical introduction:

We want to focus on the characteristic features of transmission lines which support TEM wave propagation. We are considering two TEM lines, parallel-plate and coaxial line. We want to recognize the field and voltage distribution in the cross-section of these lines and how we can control the characteristic impedance of these lines.

$\boldsymbol{p} = \mathbf{10}$ (last number from my student number is **5**, 5 is bigger or equal than 5, so my p is equal to 5 + 5 = 10)

2a) I set the width of the parallel plate line to **10** [mm].

Cut-off frequency of $TE_{10}\ mode$

$$f_{c,1,0} = \frac{c}{2a} = \ 11{,}45038168\ \text{GHz}$$

$$f = 1.1\ \times\ f_{c,1,0} = 12{,}59541985\ \text{GHz}$$

I observe **H_y, E_z** EM component in the parallel plate section

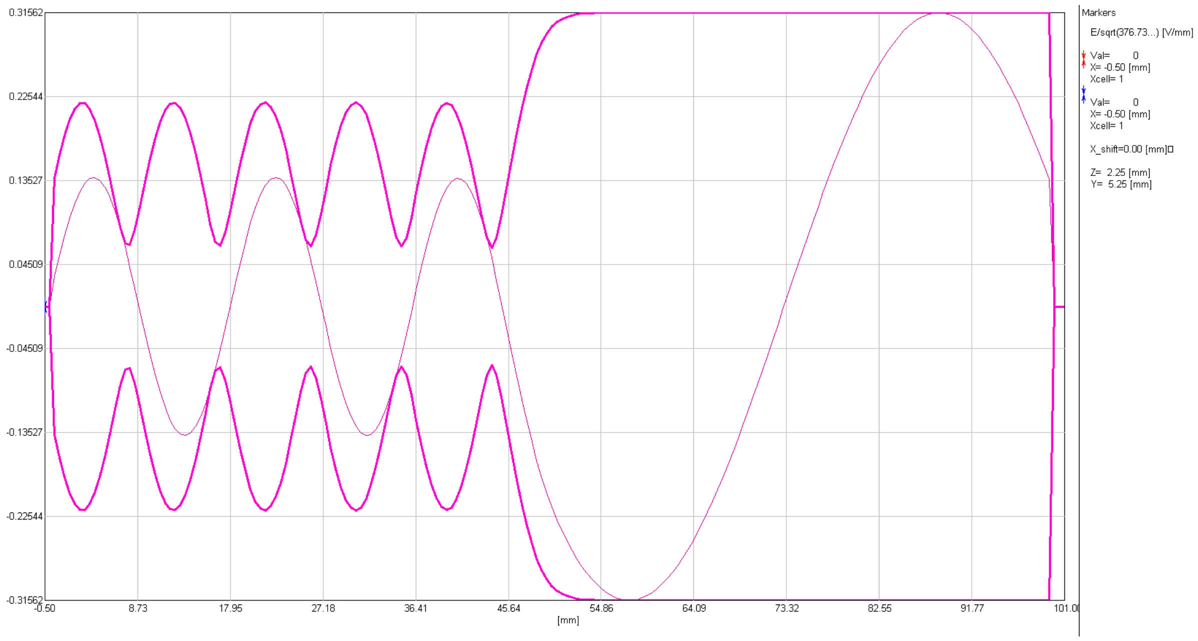
I observe **H_x, H_y and E_z** EM component in waveguide section

We can see it on the pictures

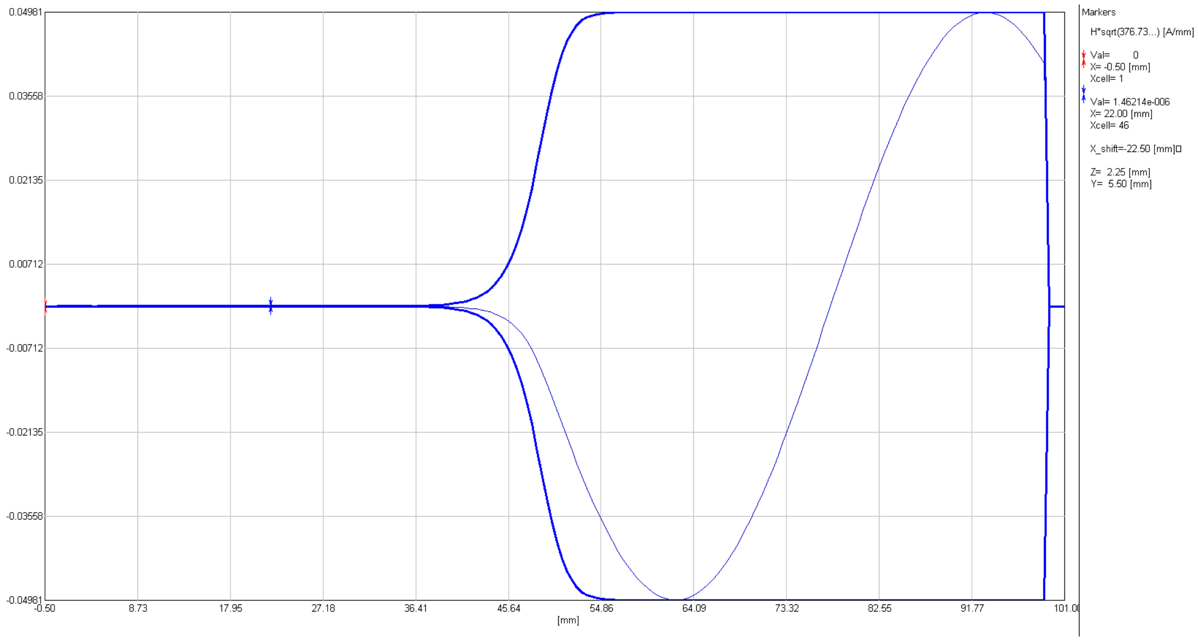
We call these mode TE_{10} in rectangular waveguide and TEM in parallel plate.

Distribution of relevant EM components I observed in the waveguide section:

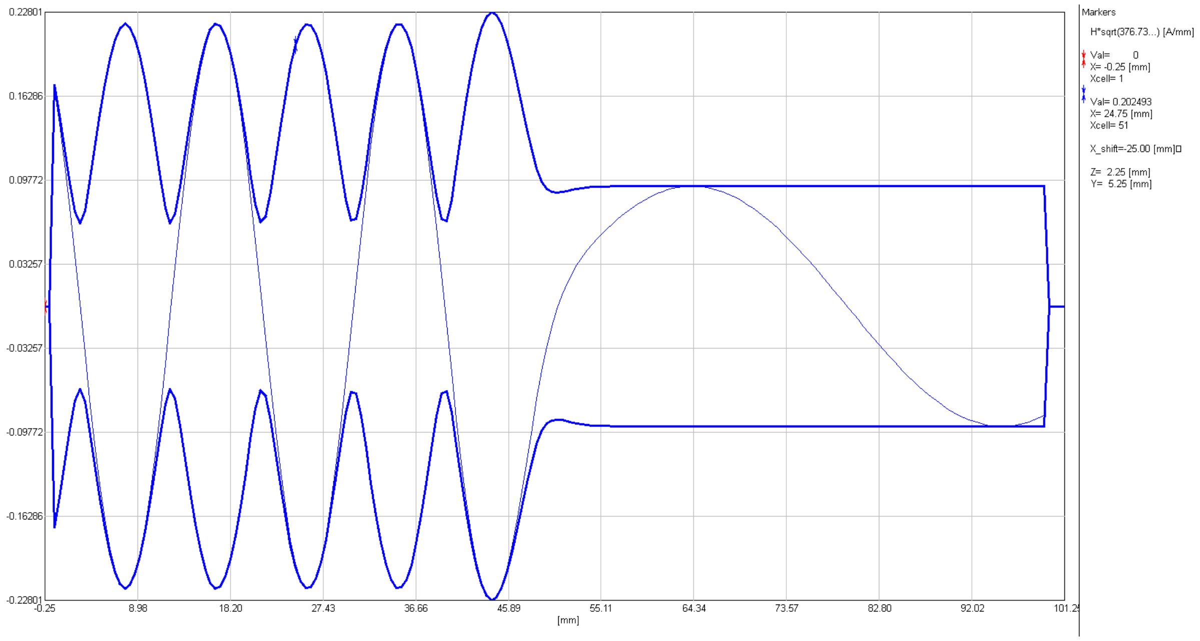
Ez



H_x



H_y



Mathematical function describing the shape of magnetic component for parallel part is **cosinus** and for waveguide is **sinus**

Mathematical function describing the shape of electric component in parallel part is **sinus** and in waveguide is **cosinus**

The wavelength in first section (parallel) is: **43 mm**

The wavelength in second section (waveguide) is: **18 mm**

Wavelength from theoretical calculations in first (parallel section) is **43,64[mm]**

Wavelength from theoretical calculations in second (waveguide section) is **18,18 [mm]**

Comparison: **First section: Difference is 0,64 mm**

Second section: Difference is 0,18 mm

2b)

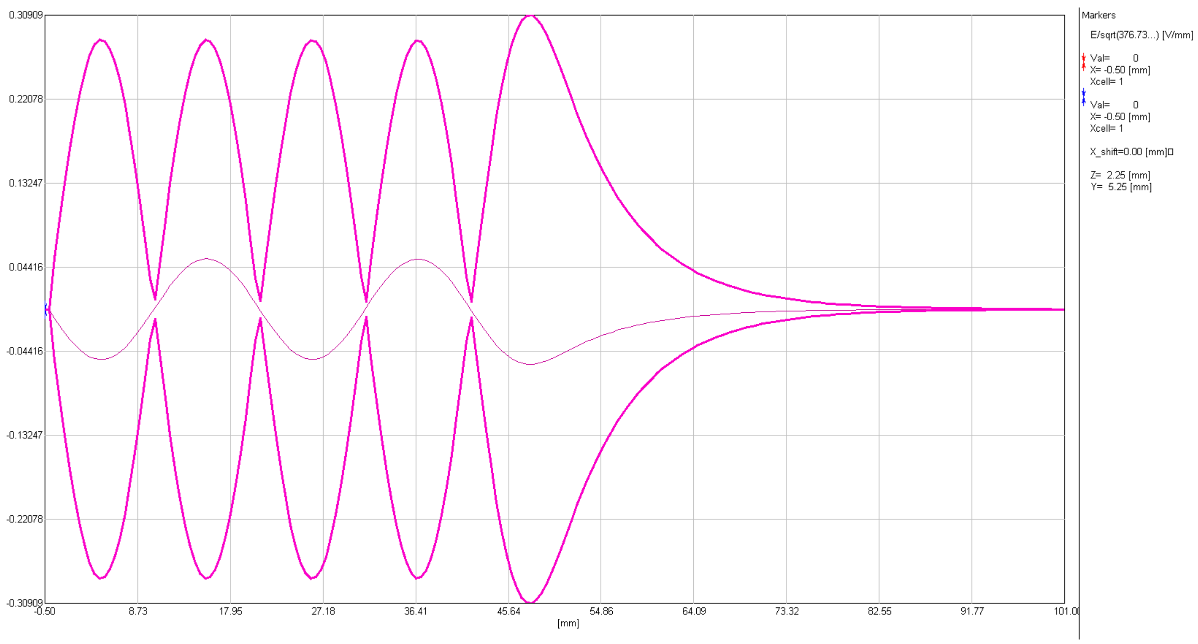
Excitation frequency at input port is:

$$f = 0.95 \times f_{c,1,0} = 10{,}8778626 \text{ GHz}$$

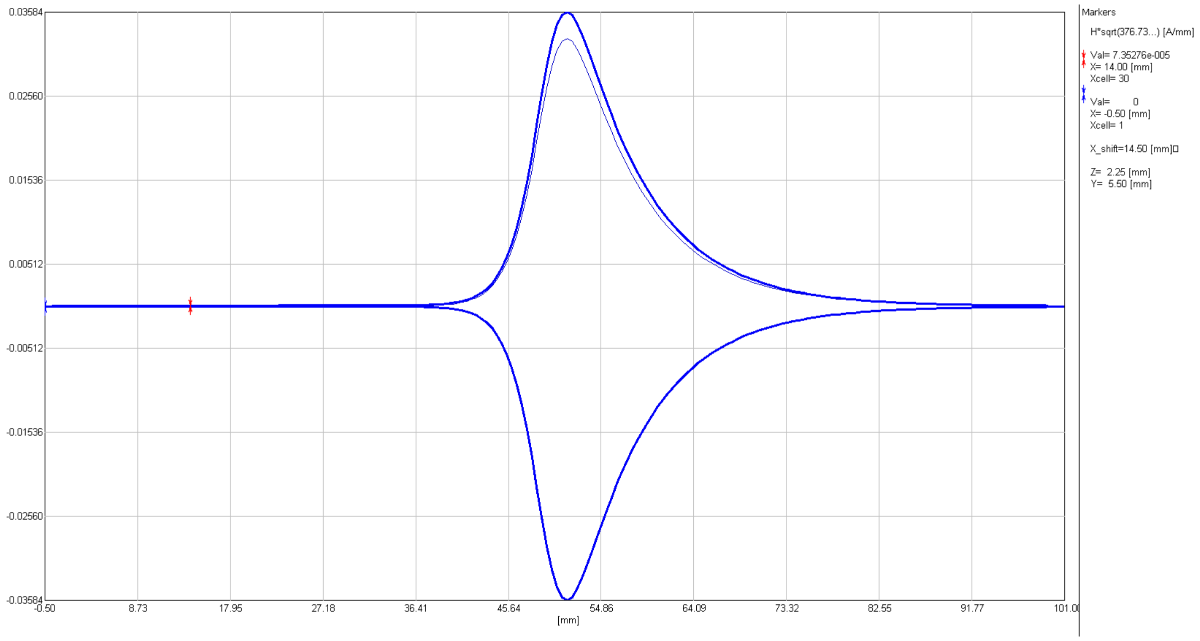
At the transition between the parallel-plate and waveguide line happens **Amplitude of electric and magnetic field decreases because it can't exist below cut-off frequency.**

Envelope along the line sketch:

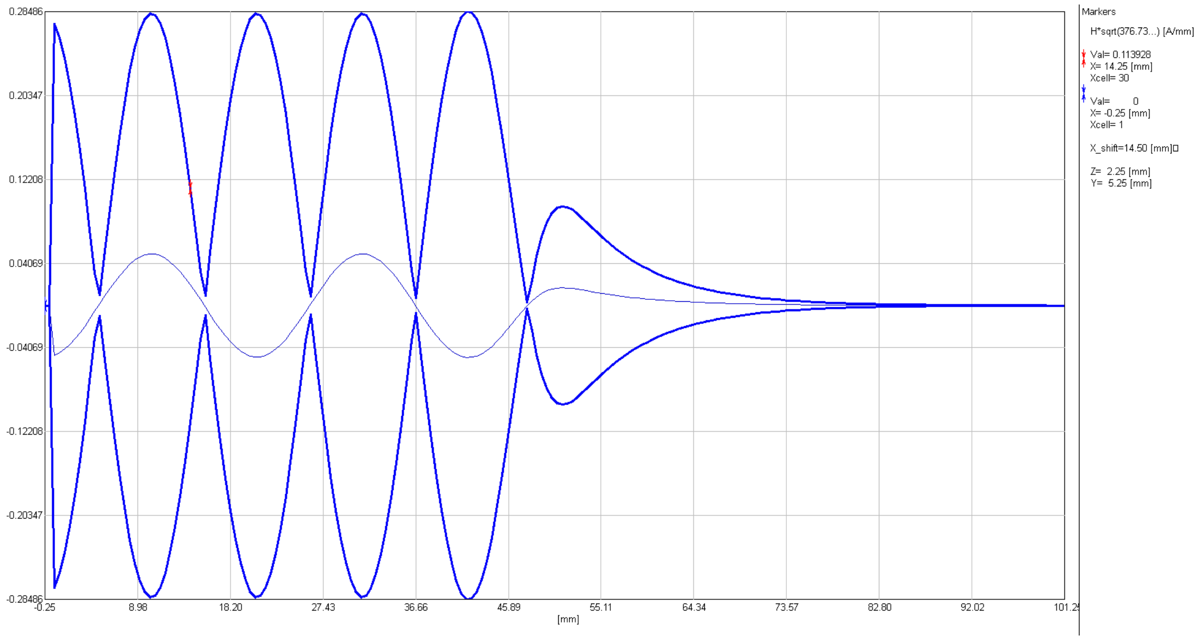
E_z

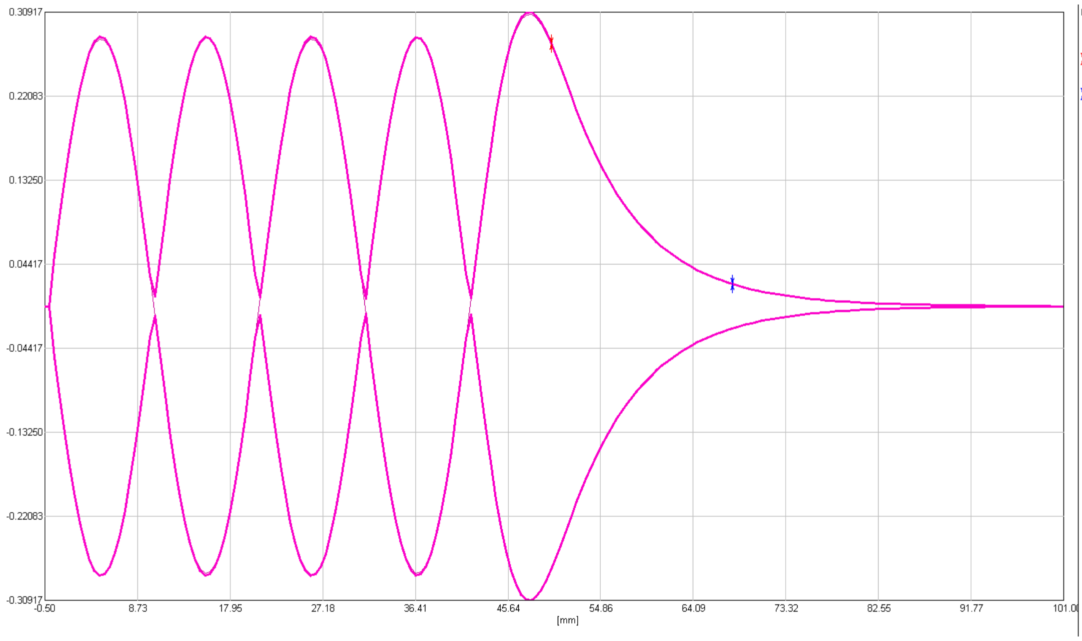


H_x


0.03584
0.02560
0.01536
0.00512
-0.00512
-0.01536
-0.02560
-0.03584
-0.50
8.73
17.95
27.18
36.41
45.64
54.86
64.09
73.32
82.55
91.77
[mm]
Markers
H*sqrt(376.73...) [A/mm]
Val= 7.35276e-005
X= 14.00 [mm]
Xcell= 30
Val= 0
X= -0.50 [mm]
Xcell= 1
X_shift=14.50 [mm]
Z= 2.25 [mm]
Y= 5.50 [mm]

H_y


0.28486
0.20347
0.12208
0.04069
-0.04069
-0.12208
-0.20347
-0.28486
-0.25
8.98
18.20
27.43
36.66
45.89
55.11
64.34
73.57
82.80
92.02
[mm]
Markers
H*sqrt(376.73...) [A/mm]
Val= 0.113928
X= 14.25 [mm]
Xcell= 30
Val= 0
X= -0.25 [mm]
Xcell= 1
X_shift=14.50 [mm]
Z= 2.25 [mm]
Y= 5.25 [mm]

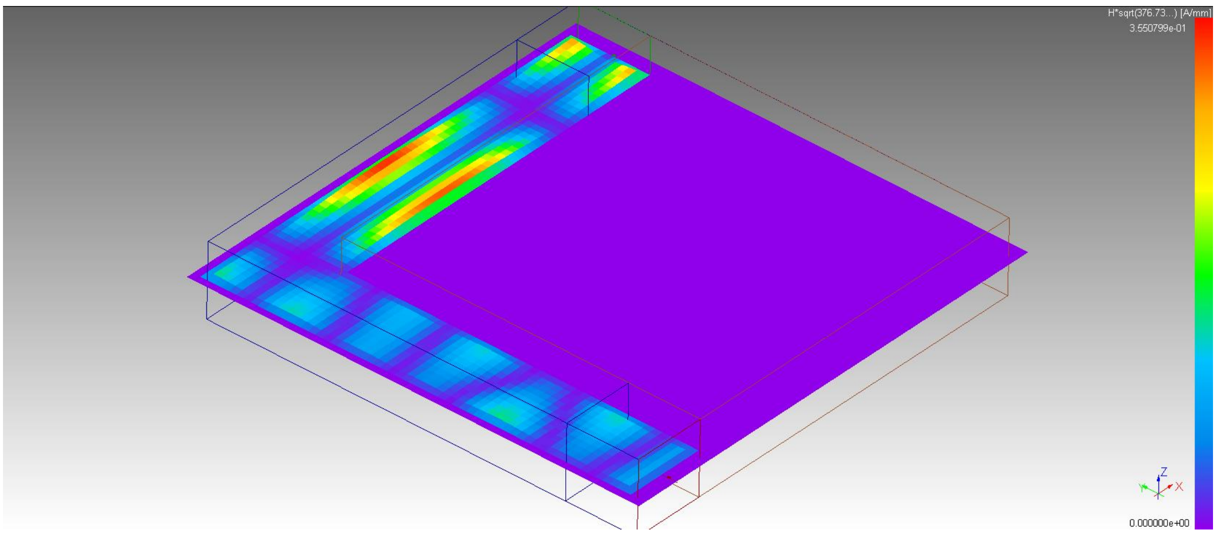


Attenuation coefficient:

$$\alpha = \frac{1}{x_2\text{-}x_1}\ln\left(\frac{E(x_1)}{E(x_2)}\right) = 0{,}137\ (1/\mathrm{mm})$$

4.

Mode TE_{10} is excited at the input port.



I can observe mode TE_{11} behind the bend

It is generated by

Cutoff frequency $f_c = \frac{\mathrm{c}}{2\mathrm{a}} = 30\ \mathrm{GHz}$

Simulation run at $f\ =\ 0.95\ f_{c,1,0} =\ 28{,}5\ \mathrm{GHz}$

The line is becoming smoother in rectangular waveguide.