

# Electromagnetism Practical, Session 1

## Transmission Lines

Rijk van Wijk 0000000, Bart Kolling 4228219, Chy Lau 0000000,  
Jasper Smit 4217527, Ian Zhang 0000000

March 29, 2016

### Assignment 1: Transmission Lines in Frequency Domain

#### Part 1: Standing Waves in Waveguide

The measured wavelength of the standing wave is 4.4 cm. The phase velocity is determined by equation 1. The wavelength in the waveguide is determined by equation 2 with an  $a$  of 22.86 mm at a frequency of 9.475 GHz. The result is that the phase velocity is  $v = 1.39c$ . This is the case because the wavelength is modified inside the waveguide.

$$v_p = \frac{\lambda}{T} \quad (1)$$

$$\lambda_w = \frac{\lambda_0}{\sqrt{1 - \left(\frac{\lambda_0}{2a}\right)^2}} \quad (2)$$

#### 2.

The voltage-standing-wave ratio (VSWR) of different loads is measured.

##### a.

The open waveguide

##### b.

Both the short circuits give a minimum of 0.02 mV and a maximum of 80 mV. This gives a VSWR of about  $4.0 \cdot 10^3$ .

##### c.

The matched load gives a minimum of 45.4 mV and a maximum of 50.3 mV giving a VSWR of 1.11.

d.

The horn antenna gives a minimum of 45.2 mV and a maximum of 51.1 mV. This gives a VSWR of 1.13.

3.

There is no shift in antinodes in our measurement regarding the two short-circuits. This is not surprising as the difference between the 33mm and the 55mm short-circuit is exactly 22mm which is half of the wavelength.

### Additional Tasks

The dependence of the phase velocity on the wavelength can be calculated using equation 1. This gives the result in figure 1.

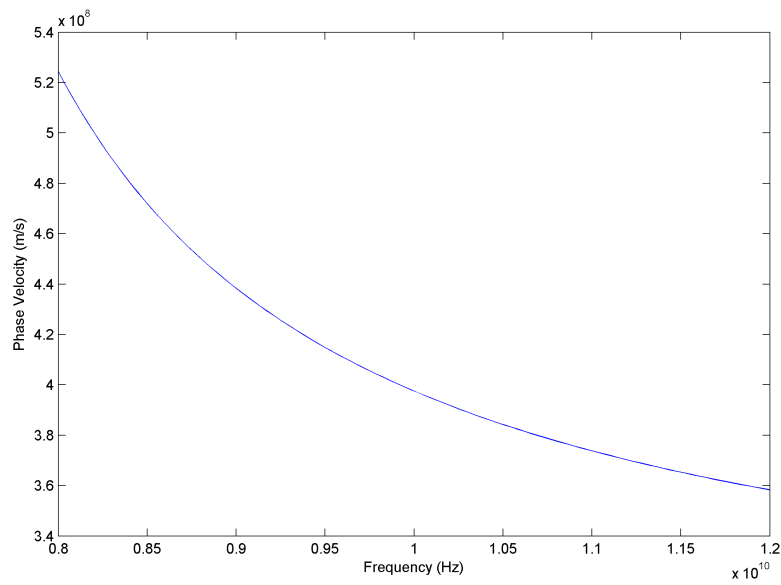


Figure 1: The phase velocity in the x-band.

Other parameters that can be estimated using the measurements are

## Assignment 2: Transmission Lines in Time Domain

### Part 1: Time Domain Reflectometry: estimate the loads impedance

$Z_l$  can be determined with equation 3. The voltage standing wave ration is measured as  $VSWR = \rho = 0.2$  and our  $Z_0 = 50\Omega$

$$\rho = \frac{Z_l - Z_0}{Z_l + Z_0} \quad (3)$$

$$Z_l = -\frac{\rho + 1}{\rho - 1} \cdot Z_0 = 75\Omega \quad (4)$$

### Part 2: Dielectric in Coaxial Cable: the Estimation of the Propagation Speed and Relative Permittivity

From the reflections the propagation velocity turned out to be  $0.77c$ , which is exactly what the datasheet of the cable states[1]. Using equation 5 the relative permittivity  $\epsilon_r$  can be calculated.

$$v = \frac{c}{\sqrt{\epsilon_r}} = 0.77c \quad (5)$$

$$\epsilon_r = \left(\frac{c}{v}\right)^2 = 1.69 \quad (6)$$

## References

- [1] Helmut Singer Elektronik. Sucoflex 104. URL  
<http://www.helmut-singer.de/pdf/sucoflex104pb.pdf>.