Notes on the 3rd year Microwaves practical

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1 Introduction

This practical consists of two investigations of the properties of transmission in a waveguide. This waveguide has approximate dimensions of X x Y cm and is transmits at frequencies around 3 GHz. The equipment consists of a frequency generator, a waveguide with a slit cut into it and a movable probe and a chart recorder.

2 Determining the waveguide equation

Make sure that the perspex block is removed from the waveguide, and place the small brass bung in the end. This reflects the transmitted waves and sets up standing waves in the guide. By moving the probe over the slit region and recording the signal on the chart you can measure the wavelength in the guide and determine the relationship between the wavelength in the guide and the wavelength in free space (since the frequency generator tells you what the frequency of the wave). You should also be able to determine the cutoff frequency in the guide. The theory of waveguides is covered in the 3rd year electromagnetism and most texts also cover it. Recall that

$$\frac{1}{\lambda_{wg}^2} = \frac{1}{\lambda^2} - \frac{1}{\lambda_{cut}^2}$$

The cutoff frequency for the dominant $TE_{1,0}$ mode in a rectangular waveguide with dimensions $a \times b$ and $a > b$ is given by

$$\lambda_{cut} = 2a$$

3 Boundary value problem

Remove the reflecting bung from the end of the waveguide and insert the perspex block. A wave transmitted in the guide will be partially transmitted and partially reflected at the boundary into the perspex and again partially transmitted and partially reflected at the boundary leaving the perspex. So before and in the perspex there will be two waves, one transmitted on reflected and beyond the perspex there is only the transmitted component.

The problem can be treated in the same manners as a potential barrier problem in quantum mechanics, or from an electromagnetism standpoint as a boundary value problem. The wave amplitude and its derivative must be continuous at the boundaries of the perspex and free space. Alternatively you can consider how the presence of a lossless dielectric effects the waveguide equation and use an approach similar to that for the first part of the experiment.

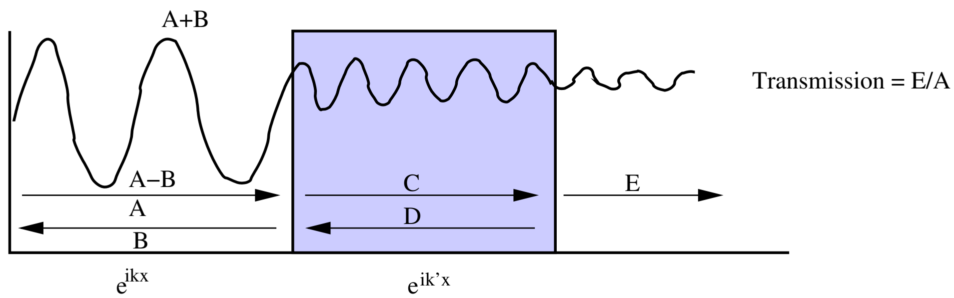

Figure 1: The effect of perspex on the propagation in a waveguide

There are a number of parameters to determine, the power coefficients of transmission T and reflection R for the perspex and the associated dielectric constant κ_e and the wavenumber k in the perspex. They will measure k in the waveguide and have to work out how that relates to k in free space.

4 Equipment

The data is recorded via an analogue to digital converter connected to an old PC. The software to record the data is a program called `picologger` which is the executable `plw.exe` in the directory `C:`
`PICO`. Running this program (there is also a link on the desktop) gives you two windows, the PLW Monitor window and the PLW Recorder window.

To configure the Pico analogue to digital converter ADC-212 you need to use the Settings menu in the Monitor window.

- In the recordings tab, set real time continuous and stop at the end.
- In the input channels tab - select ADC-20, channel 1 and then conversion time 60ms (shortest possible) and voltage range ± 1250 mV.
- In the sample tab - 100ms

After adding a configuration you should see a green light icon in the Monitor window and a reading in mV from the sensor. Move the sensor along the waveguide by hand and you should see the voltage reading vary if you have a signal into the waveguide. The Recorder window is now used to choose or name a new file, and start/stop the recording. The recording sampling rate can be accessed in the Monitor window, Settings menu.