University of Victoria

ELEC 340

Applied Electromagnetics and Photonics

Lab 4 - Oblique Incidence and Waveguides

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A01 - B03

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1 Objective

Purpose of the lab.

2 Introduction

Short section on the background and motivation i.e. what the experiment is about and what is being measured [1].

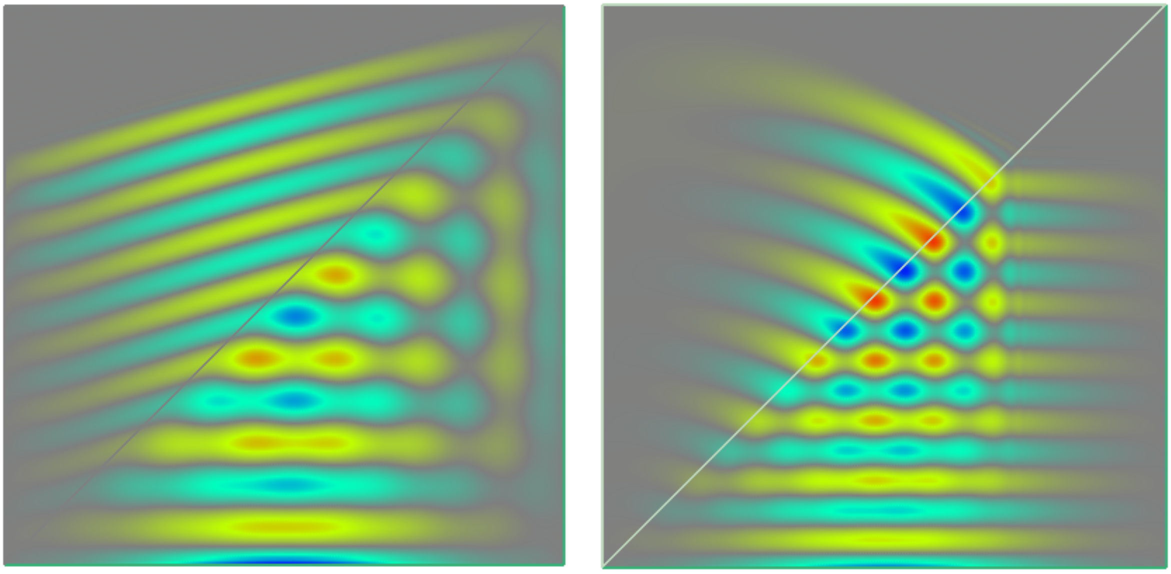
3 Procedure

Overview of lab sequence.

4 Discussion

4.1 Snell's Law

Task 4 *Compare the angles of incidence, reflection and transmission in an air* $\rightarrow \epsilon_r = 2$ *and* $\epsilon_r = 2 \rightarrow$*air interface.*



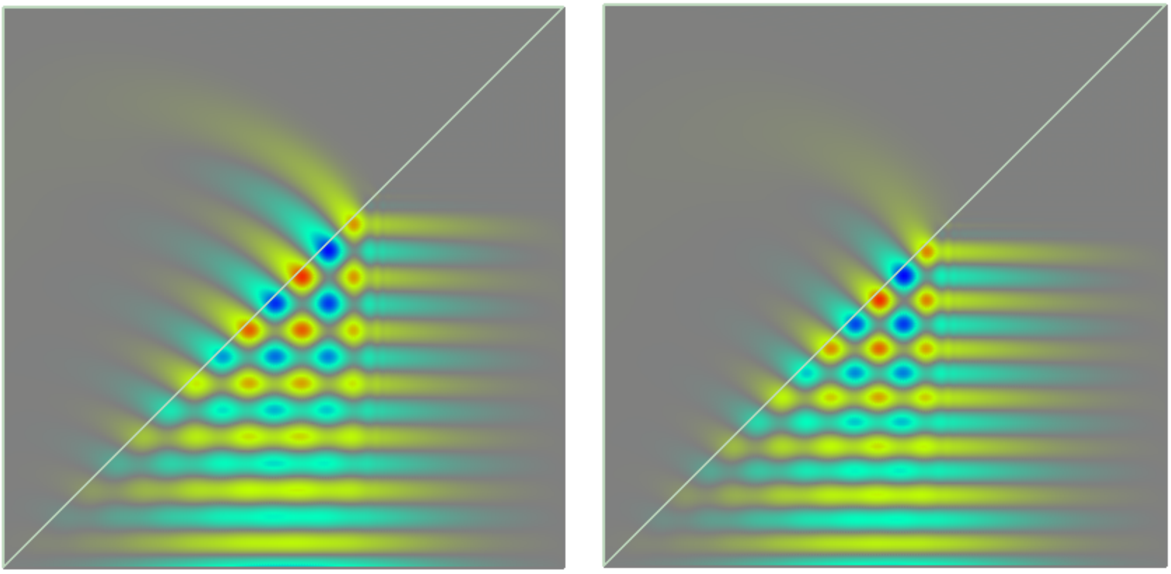
(a) $\epsilon_r = 1 \rightarrow \epsilon_r = 2$

(b) $\epsilon_r = 2 \rightarrow \epsilon_r = 1$

Figure 1: Behavior at 45° incidence

Compute the angles of reflection and transmission

Task 6 *Compare the images for $\epsilon_r = 2.0, 2.5, 3.0$ in the ABC-bounded region.*



(a) $\epsilon_r = 2.5 \to \epsilon_r = 1$ (b) $\epsilon_r = 3 \to \epsilon_r = 1$

Figure 2: Behavior at 45° incidence

Compute the TIR angles for the 2, 2.5, 3 to 1 interface.

Why does the "spray" into the second medium decrease as ϵ_r increases?

Task 8 *Capture an animation of* **H** *with pointer mode and comment on it.*

As **E** is reflected by the boundary it creates a standing wave, perpendicular to the plane of Fig. 3. As per Ampere's Law, **H** curls around the perpendicular **E** field, creating the "pools" in the image.

Fig. 4 shows that **H** is not altered by the boundary. Since **E** was reflected by the boundary, **H** dissipates because it is not able to generate itself in isolation.

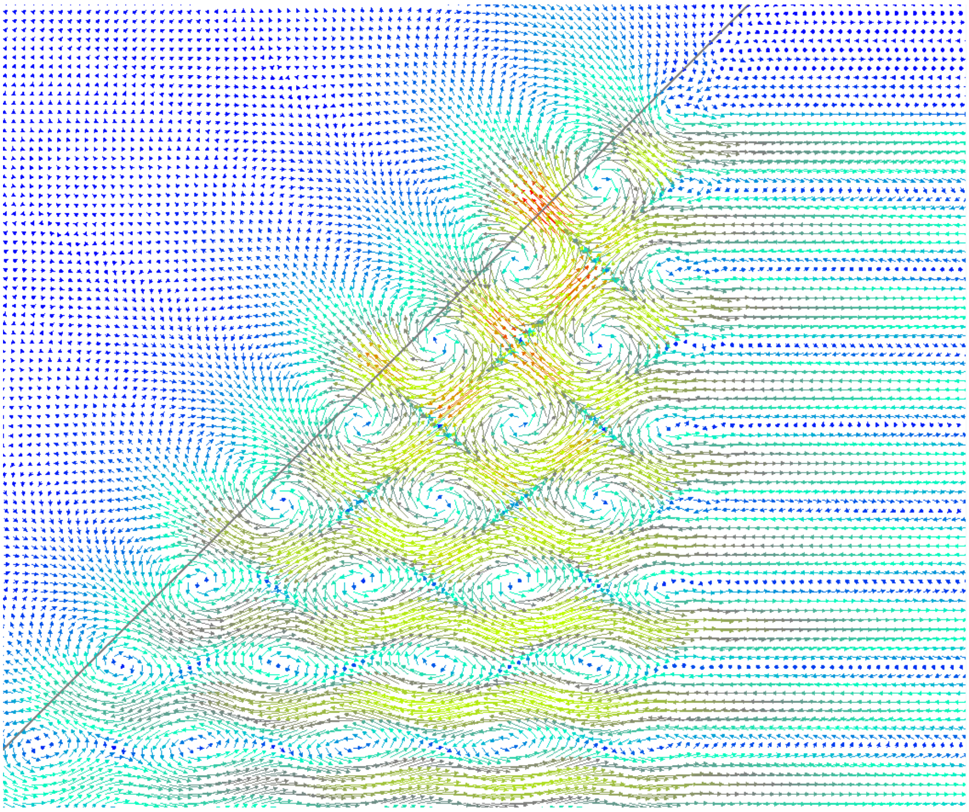


Figure 3: $\mathbf{H}$ for $\epsilon_r = 3 \rightarrow \epsilon_r = 1$

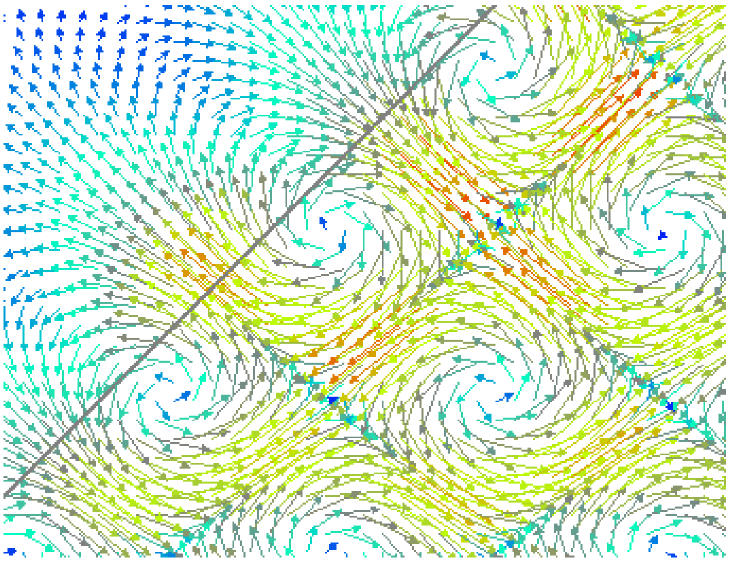


Figure 4: Inset view of Fig. 3

4.2 Brewster angle

Task 9 *Design a Brewster angle interface for zero reflection transmission of a plane wave from air to a dielectric with* $\epsilon_r = 4$*.* The Brewster angle for this interface is:

$$\tan\theta_B = \sqrt{\frac{\epsilon_2}{\epsilon_1}} \implies \theta_B = \tan^{-1}(2) = 63.435°$$

The second medium is designed with a base of 200 mm and height of 400 mm to ensure an incidence angle of θ_B. This is shown in Fig. 5.

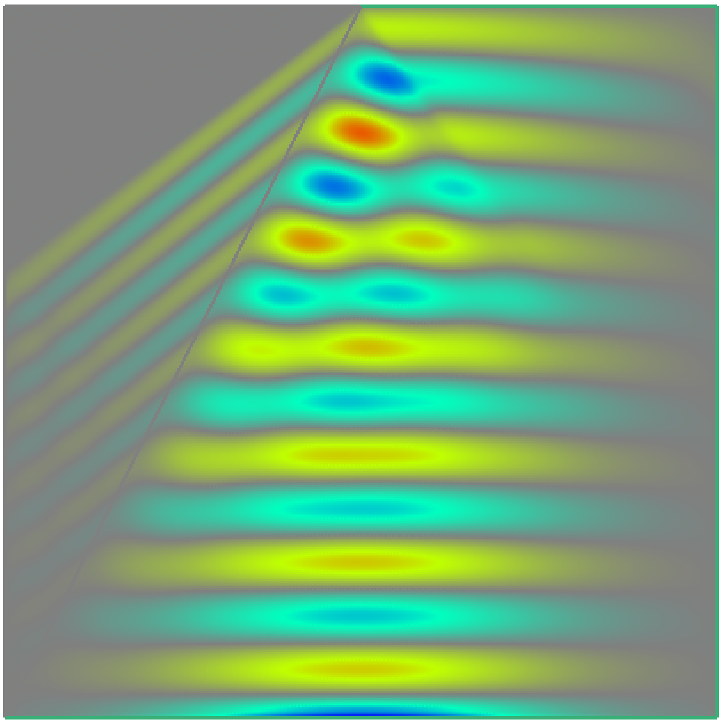


Figure 5: A Brewster angle interface

4.3 Rectangular waveguides and cavities

Task 16 *Obtain the resonant frequencies of the constructed waveguide and compare it to the calculated values.*

Fig. 6 shows the response generated by the impulse function.

For TE_{11}, the cutoff frequency is:

$$f_c = \frac{u_{p0}}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2} = \frac{c_0}{2}\sqrt{\left(\frac{1}{30\,\text{mm}}\right)^2 + \left(\frac{1}{20\,\text{mm}}\right)^2} = 9.007\,\text{GHz}$$

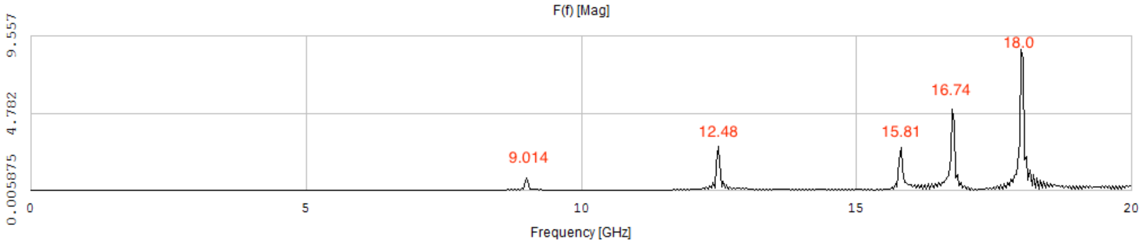


Figure 6: Frequency response of waveguide

verify calculation

This corresponds with the first peak of Fig. 6.

4.4 Rectangular waveguide modes

Task 20 *Compare the propagation in a waveguide with TE_{10} and TE_{30}.*

TE_{30} has $f_c \approx 4.5\,\text{GHz}$. Any frequency above this value with propagate through the waveguide, but significantly higher frequencies will generate the best graphics. Fig. 7 was generated with a source at $50\,\text{GHz}$

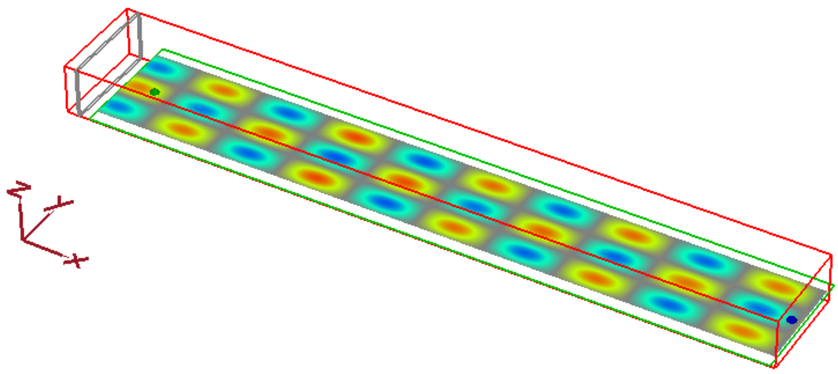


Figure 7: Transmission in a TE_{30} waveguide

5 Conclusion

Summarize the entire report and note any unresolved issues. This section will usually repeat the abstract.

References

[1] P. P. M. So, *Laboratory Manual for ELEC340 - Applied Electromagnetics and Photonics*, University of Victoria, 2016.