

DEPARTMENT OF ELECTRICAL, ELECTRONIC AND COMPUTER ENGINEERING

ANTENNAS AND MICROWAVES
EMZ 320

PRACTICAL 2 REPORT: FIELDS IN A WAVEGUIDE

2012-09-28

NAME	STUDENT NUMBER	CONTRIBUTION
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Student number: [redacted]; 29042951
Topic of work: Report on Practical 2

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1. Practical Preparation

The waveguide has dimensions of a = 22.86 mm and b = 10.16 mm giving it a cut off frequency of 6.56 GHz. The TE10 mode fields that will exist are shown below as well as the surface current densities.

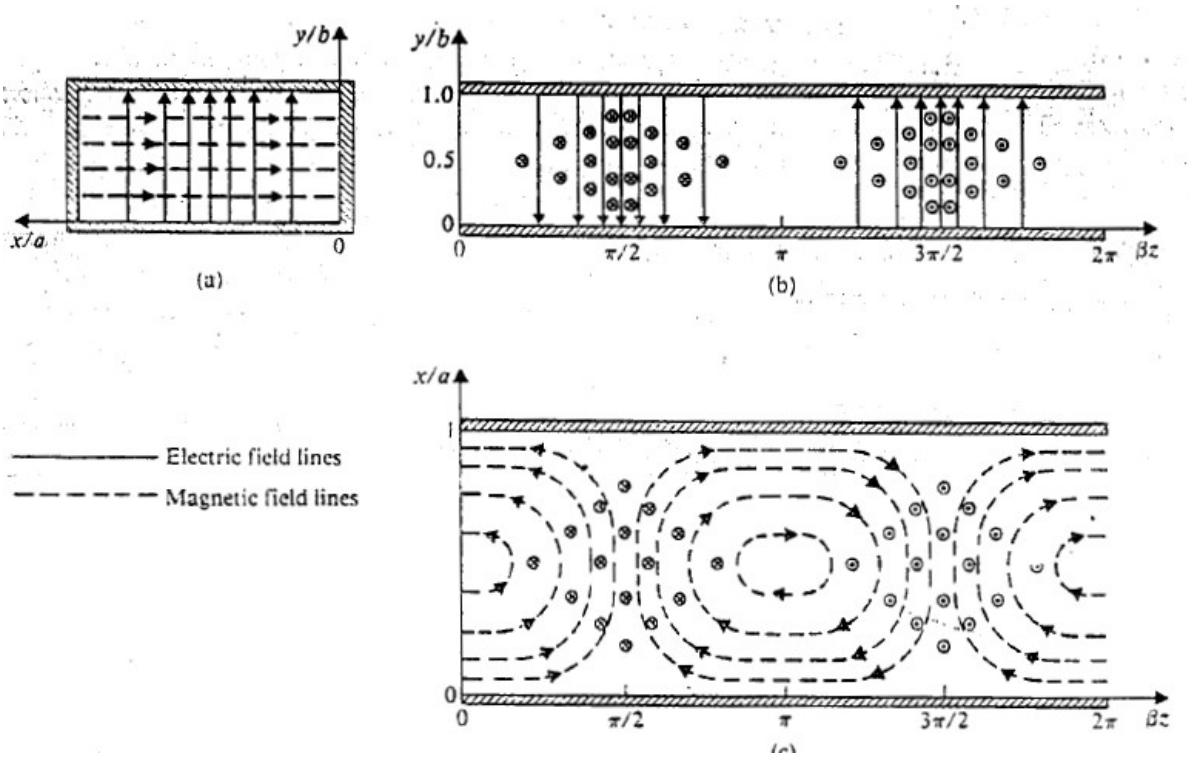


Figure 1. Field Lines Present in a Rectangular Waveguide, TE10 Mode

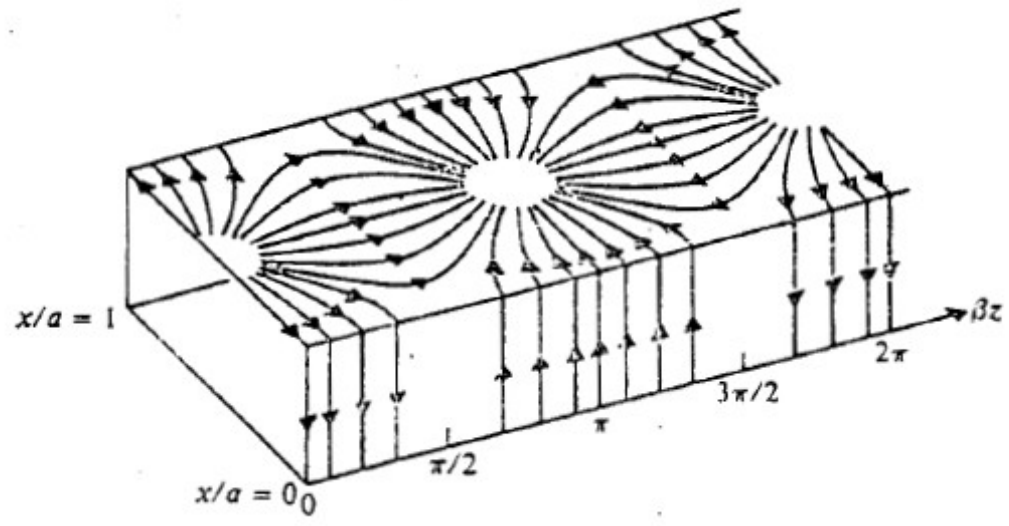
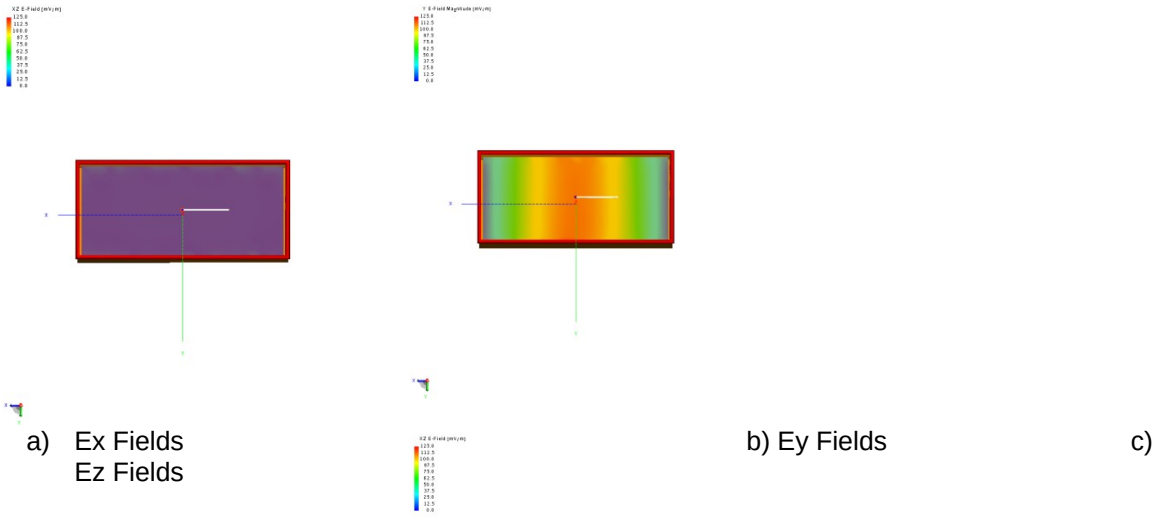


Figure 2. Surface Currents Present in TE10 Mode

The above figures are from Field and Wave Electromagnetics by David K. Cheng.

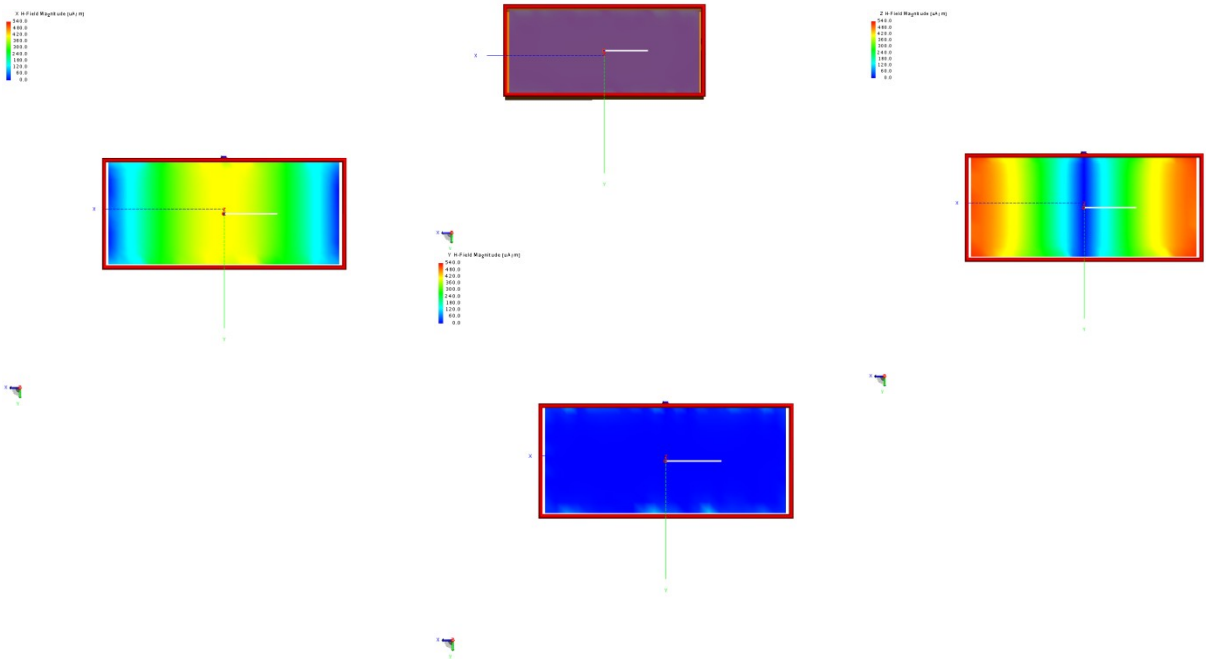
2. Simulations Results with Feed in Center of Waveguide

Firstly the fields at a frequency of 4 GHz are looked at in the cross sectional view.



a) Ex Fields b) Ey Fields c) Ez Fields

Figure 3. Cross Section of Electric Fields at 4 GHz

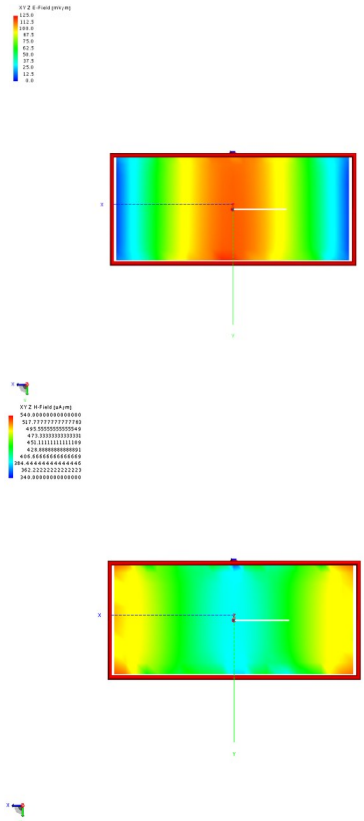


a) Hx Fields b) Hy Fields c) Hz Fields

Figure 4. Cross Section of Magnetic Fields at 4 GHz

Looking at figure 3, where an electric field has only a y-direction component, and comparing with figure 1, the front view, it can be seen that the electric field distributions are the same.

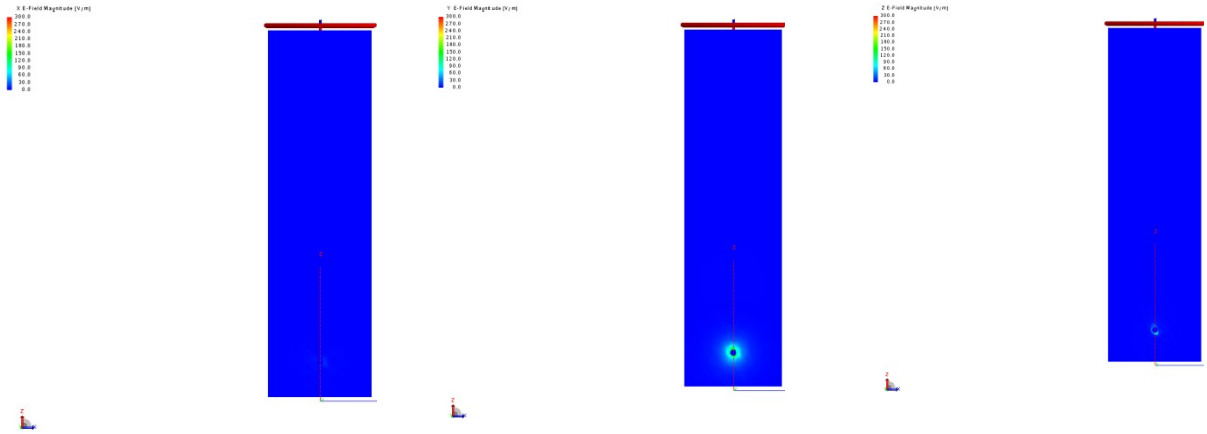
Next is figure 4, where there is not a y-direction component of the magnetic field, and comparing it with figure 1, front and side view, it can be seen that the magnetic field distributions are the same.



a) Total E Fields b) Total H Fields

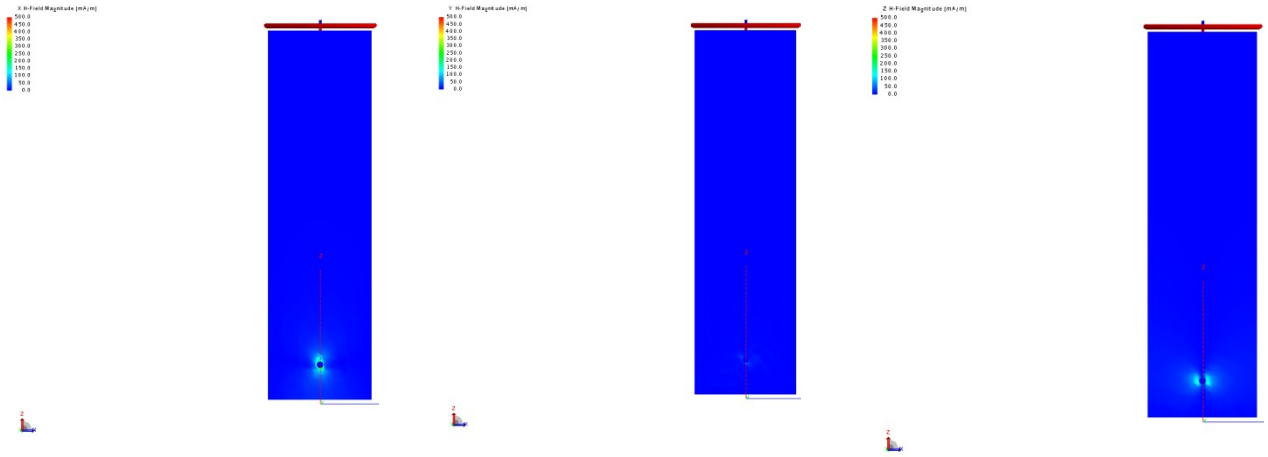
Figure 5. Cross Section of Total Electric and Magnetic Fields at 4 GHz

The figure above just shows the total electric and magnetic fields. Next the fields, still at 4 GHz are looked at in the xz-plane.



a) Ex Fields b) Ey Fields c) Ez Fields

Figure 6. XZ-Plane View of Electric Fields at 4 GHz

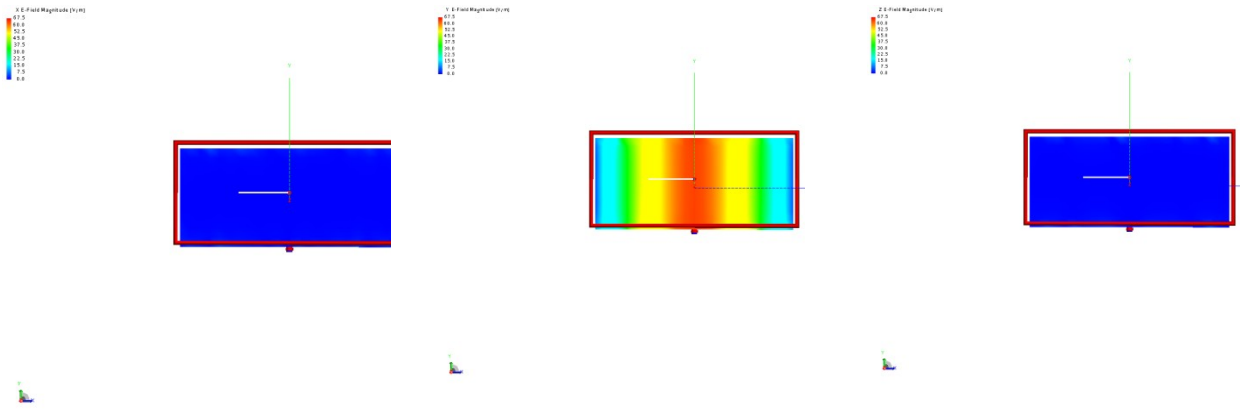


a) Hx Fields b) Hy Fields c) Hz Fields

Figure 7. XZ-Plane View of Magnetic Fields at 4 GHz

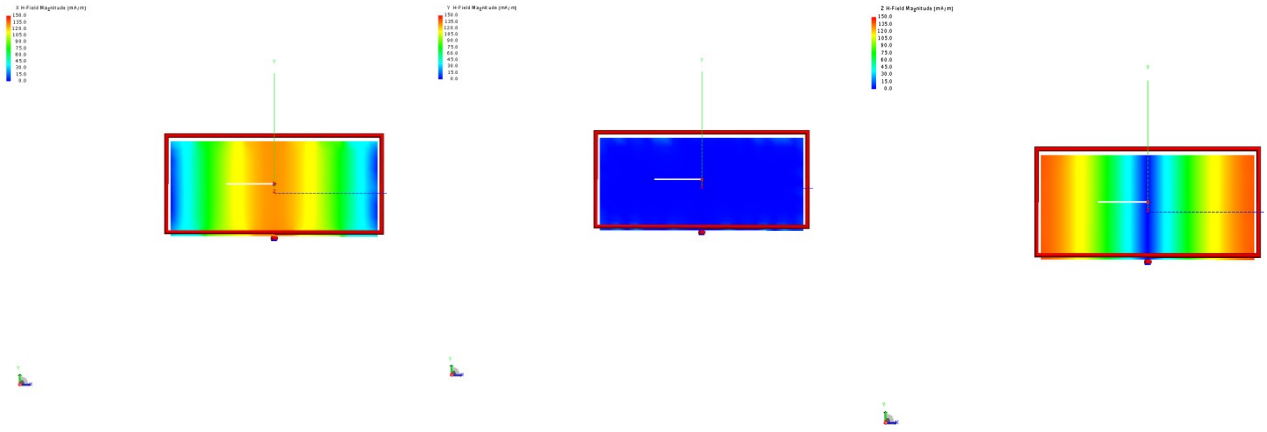
From figures 6 and 7 it is seen that neither electric or magnetic fields propagate down the wave guide because the frequency, being at 4 GHz, is below the cut off frequency, mentioned in the practical preparation section as 6.56 GHz. The total electric and magnetic fields are basically the same as a combination of Ex, Ey, and Ez in figure 6, same for figure 7 just combination of magnetic fields, no propagation down waveguide.

A look is taken at the electric and magnetic fields that are present at frequencies of 9 GHz and 14 GHz in the cross sectional view.



a) Ex Fields b) Ey Fields c) Ez Fields

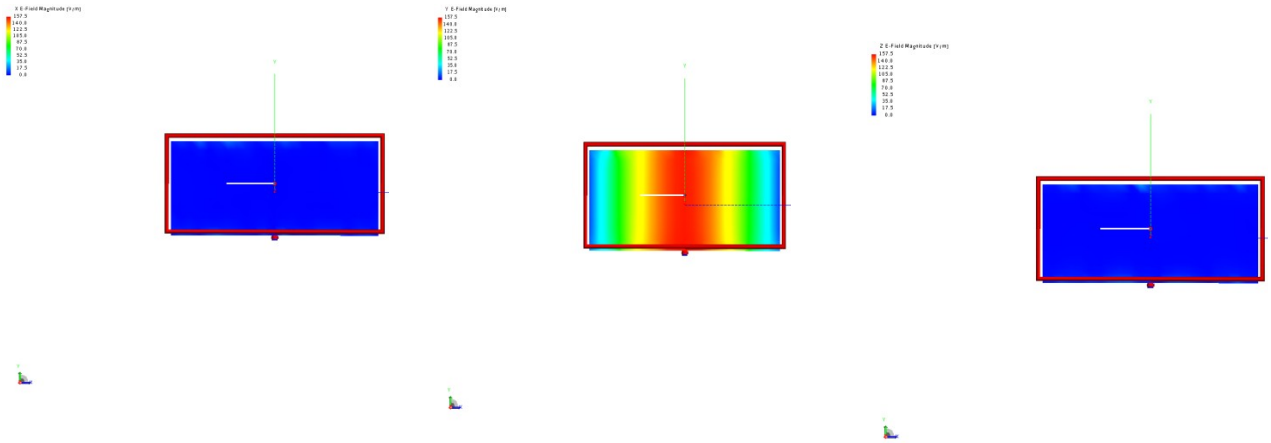
Figure 8. Cross Section of Electric Fields at 9 GHz



a) Hx Fields b) Hy Fields c) Hz Fields

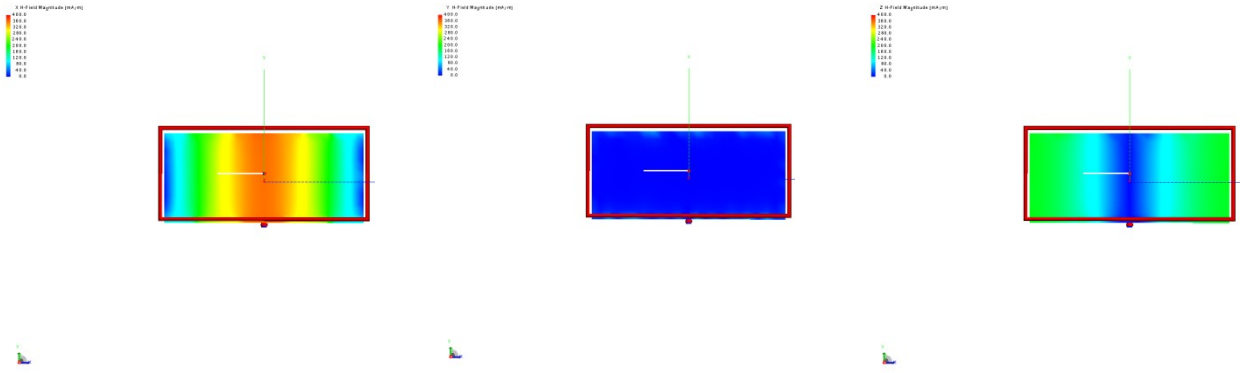
Figure 9. Cross Section of Magnetic Fields at 9 GHz

Figures 8 and 9 resemble figures 3 and 4 with the only difference being that the intensity of the fields are higher at this frequency than before. The same goes for the next two figures which are at 14 GHz.



a) Ex Fields b) Ey Fields c) Ez Fields

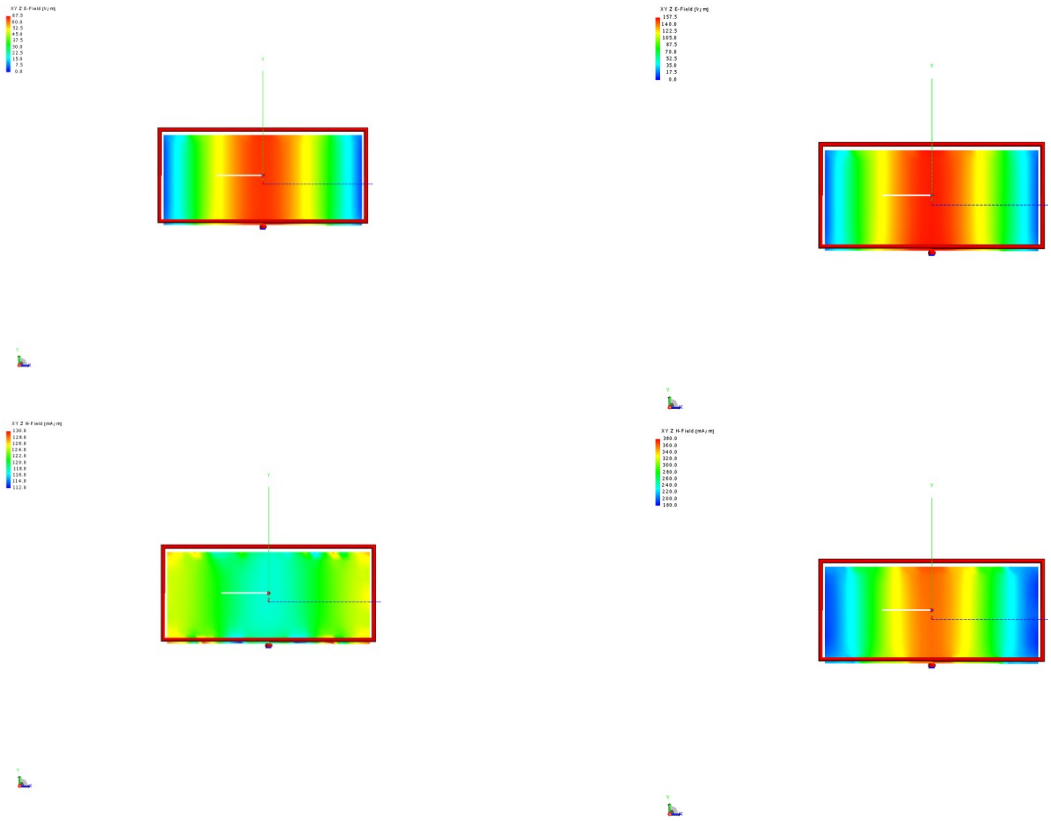
Figure 10. Cross Section of Electric Fields at 14 GHz



a) Hx Fields b) Hy Fields c) Hz Fields

Figure 11. Cross Section of Magnetic Fields at 14 GHz

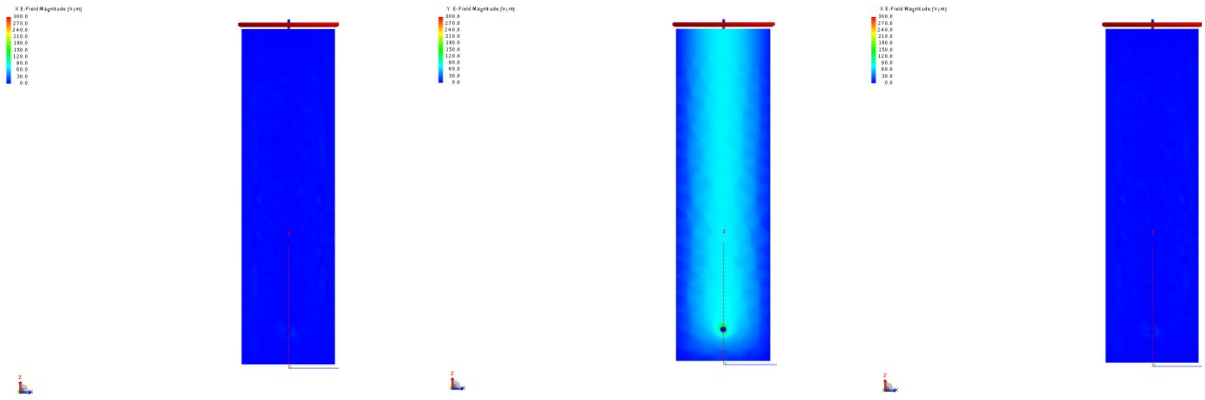
Before the fields in the xz-plane are looked at the total electric and magnetic fields, in the cross section, are shown below.



a) Total E Fields b) Total H Fields

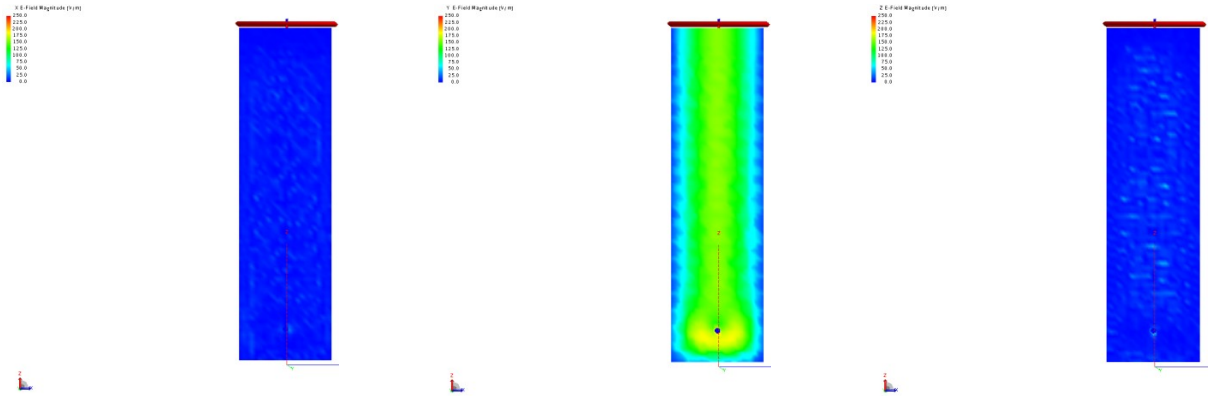
Figure 12. Cross Section of Total Electric and Magnetic Fields at 9 and 14 GHz

In figure 12 the two figures at the top are at 9 GHz and the bottom ones are at 14 GHz. Next the fields in the xz-plane of the waveguide.



a) Ex Fields b) Ey Fields c) Ez Fields

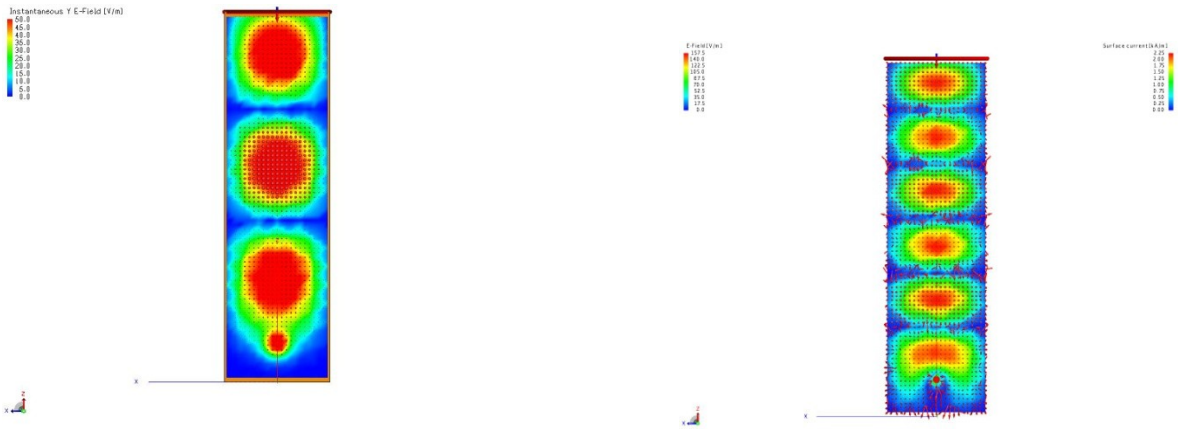
Figure 13. XZ-Plane View of Electric Fields at 9 GHz



a) Ex Fields b) Ey Fields c) Ez Fields

Figure 13. XZ-Plane View of Electric Fields at 14 GHz

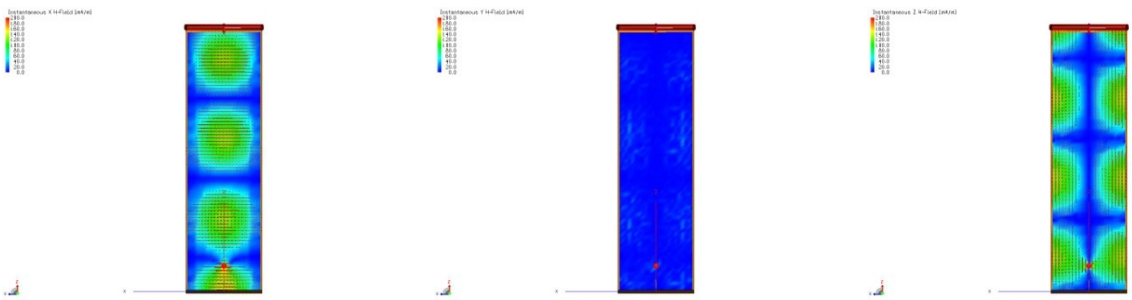
Before the magnetic fields are looked at the instantaneous electric field, is looked at in the xz-plane which will now be shown next. It more clearly represents the top view shown in the preparation section.



a) 9 GHz b) 14 GHz

Figure 14. XZ-Plane Instantaneous Ey Fields

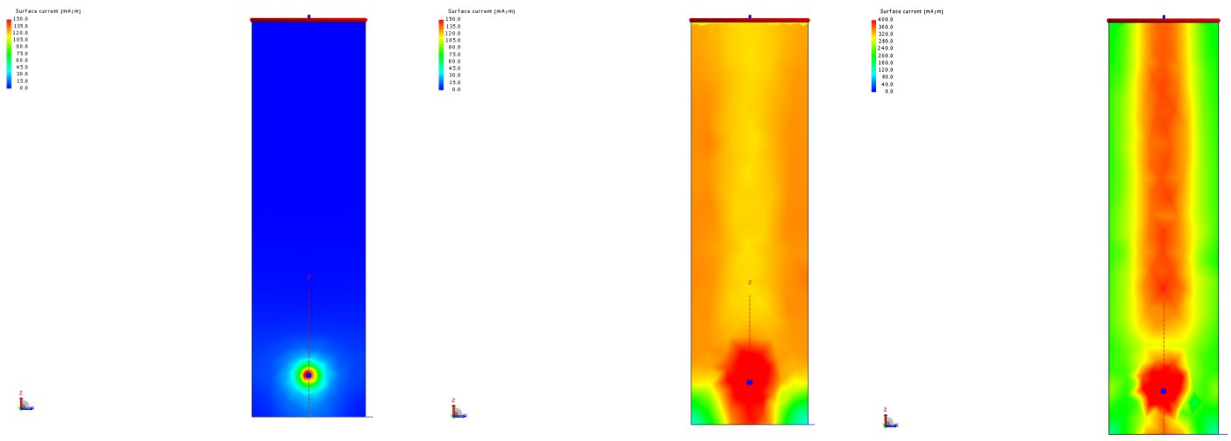
The instantaneous magnetic fields will also be look at for a more accurate depiction of the fields.



a) Hx Fields b) Hy Fields c) Hz Fields

Figure 15. XZ-Plane Instantaneous Magnetic Fields at 9 GHz

The fields in figure 15 at 14 GHz will just have a higher intensity than that shown. Figure 15 can be compared to the top and side view of figure 1 in the preparation section to see that they are the same. Before the next section this section is concluded with the figures showing the surface current densities.



a) 4 GHz b) 9 GHz c) 14 GHz

Figure 16. Surface Current Densities on Broad Side Surface

To more clearly see how the surface current density follows the magnetic field the instantaneous surface current density is looked at. The magnitude of the current density increases at the same places as the magnetic field magnitude as a result of Maxwell's equation stating that the curl of the magnetic field H is equal to current density.

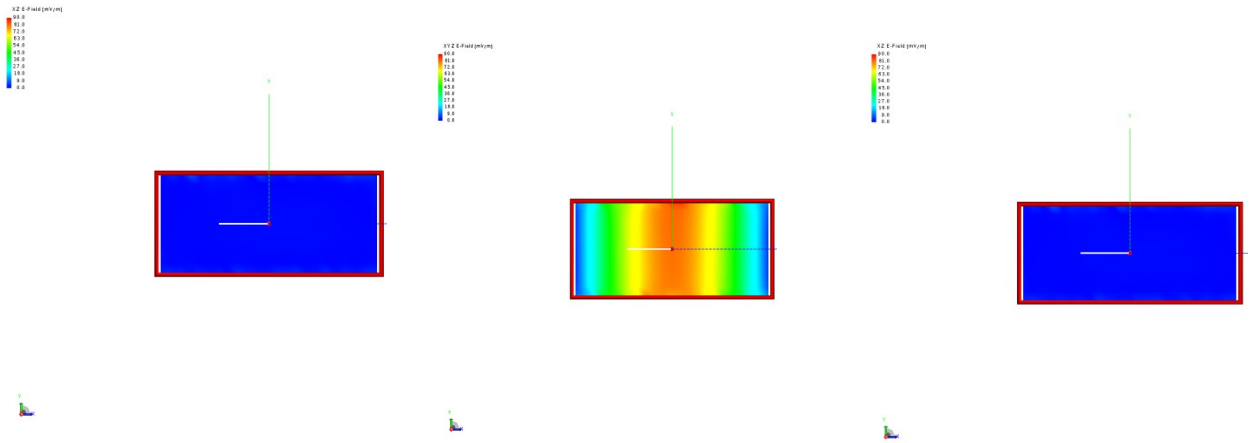


Figure 17. Instantaneous Surface Current Density at 9 GHz

Again the magnitude/intensity will be larger/higher at 14 GHz for surface current density shown in figure 17.

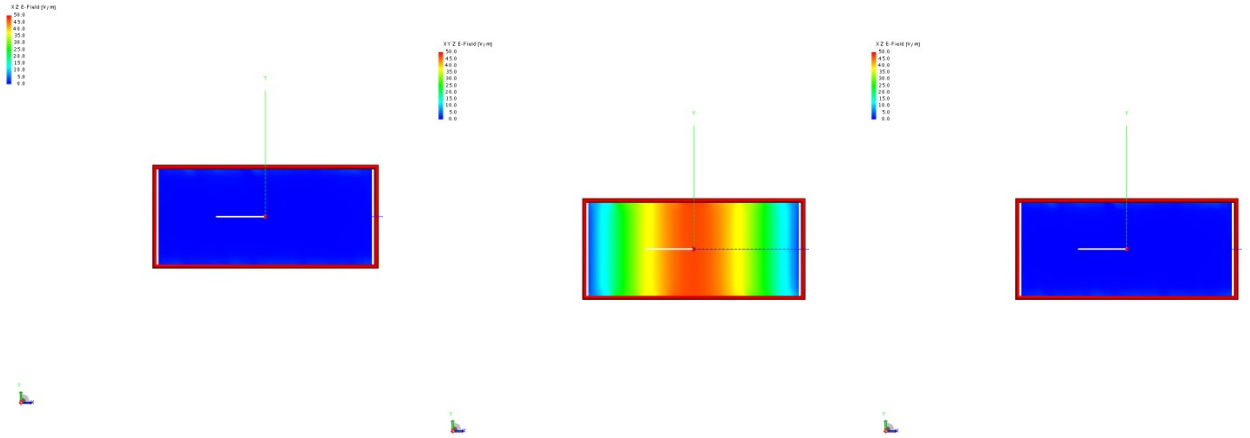
3. Simulations Results with Feed Offset in Waveguide

In this section the fields are looked at after the feed point has been shifted, which will allow different modes to exist. Firstly the electric fields are looked at in the cross sectional view. Different modes other than TE10 exist at 14 GHz as will be seen in the following figures.



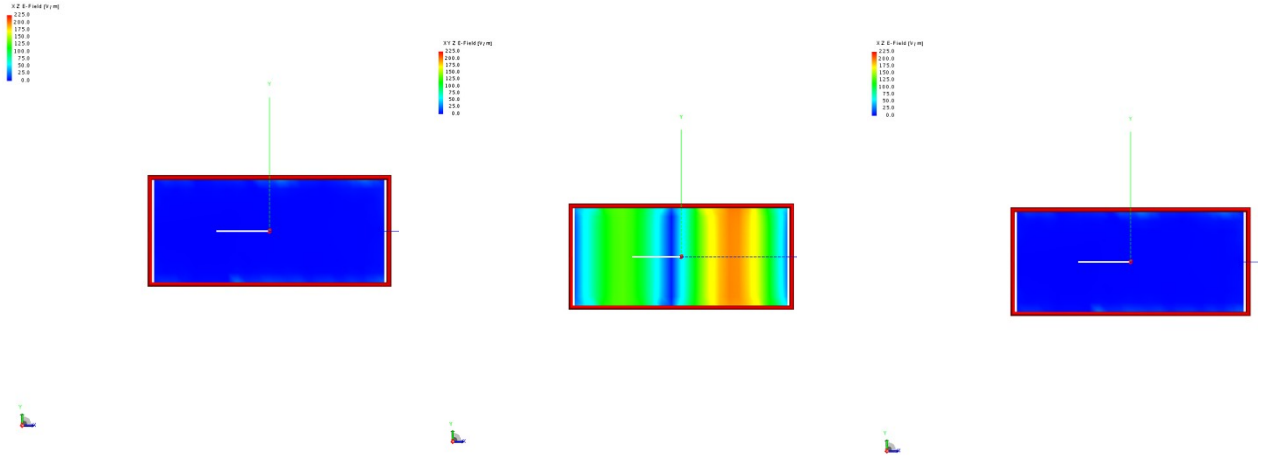
a) Ex Fields b) Ey Fields c) Ez Fields

Figure 18. Cross Section of Electric Fields at 4 GHz



a) Ex Fields b) Ey Fields c) Ez Fields

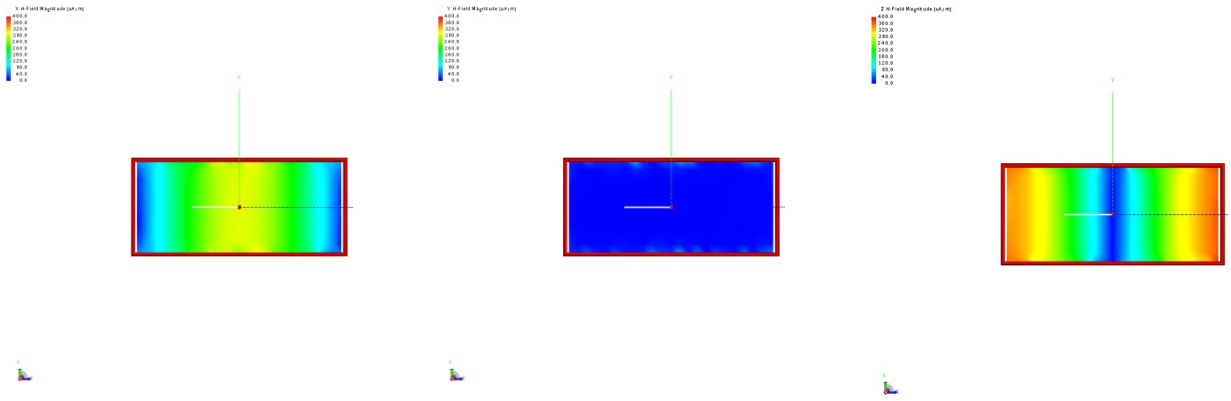
Figure 19. Cross Section of Electric Fields at 9 GHz



a) Ex Fields b) Ey Fields c) Ez Fields

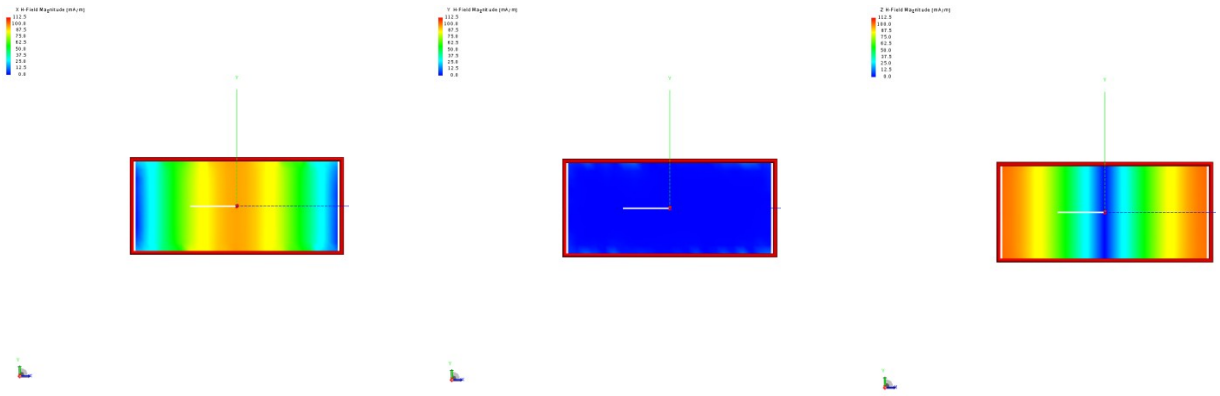
Figure 20. Cross Section of Electric Fields at 14 GHz

Now the magnetic fields are looked at in the cross sectional view.



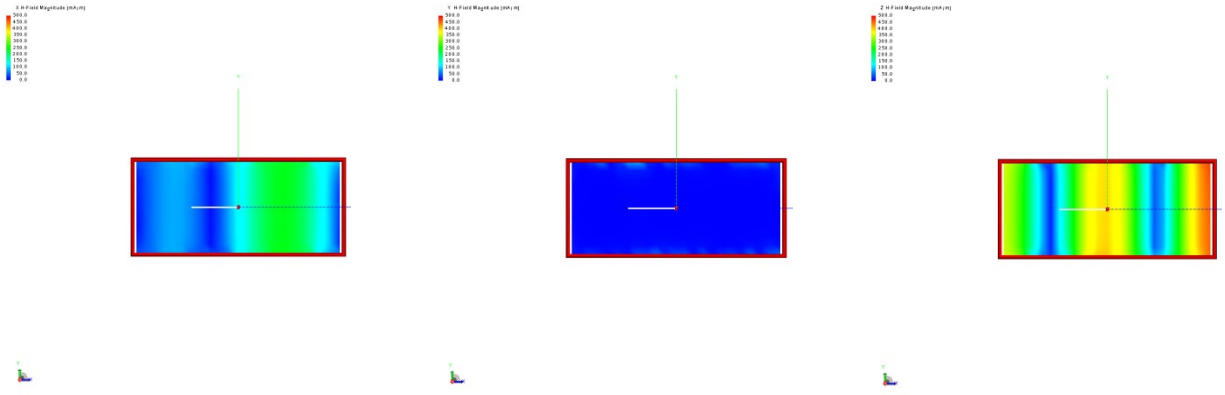
a) Hx Fields b) Hy Fields c) Hz Fields

Figure 21. Cross Section of Magnetic Fields at 4 GHz



a) Hx Fields b) Hy Fields c) Hz Fields

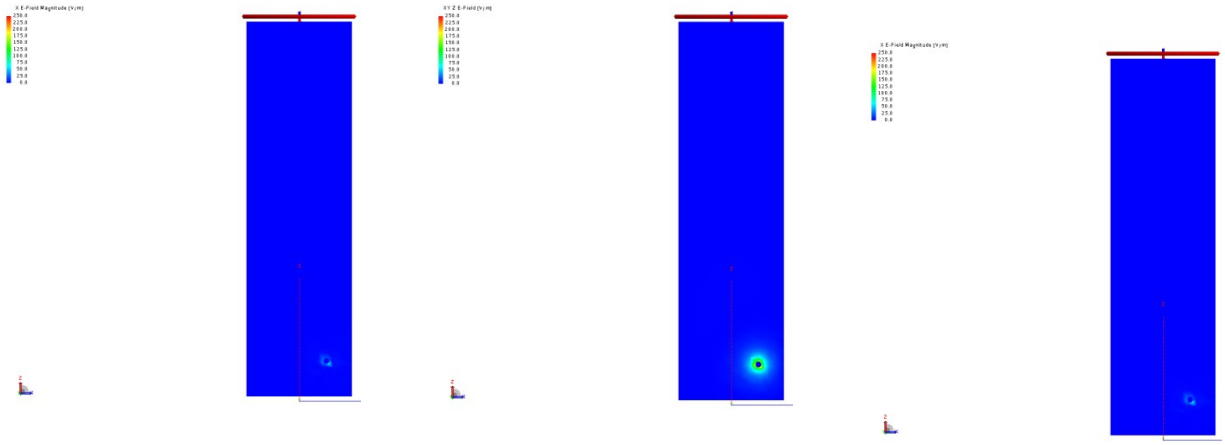
Figure 22. Cross Section of Magnetic Fields at 9 GHz



a) Hx Fields b) Hy Fields c) Hz Fields

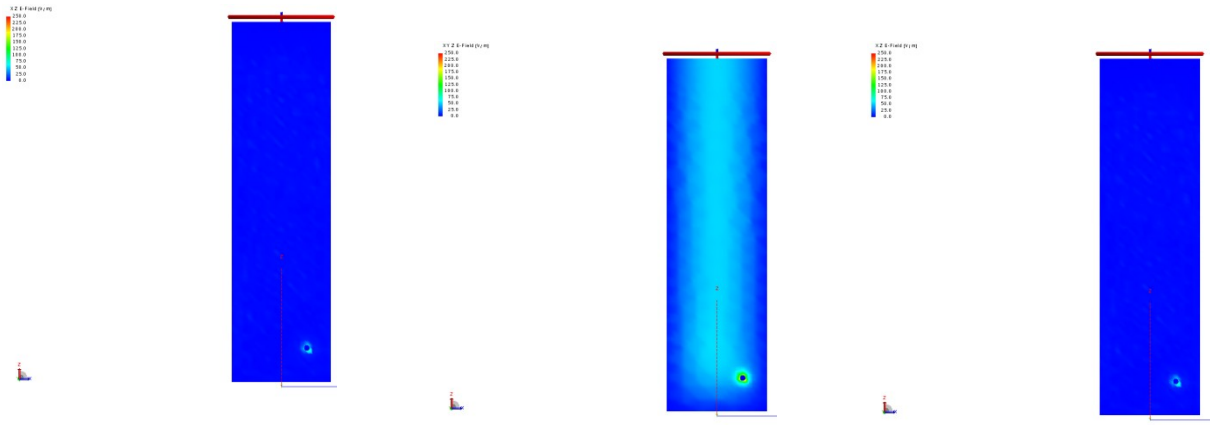
Figure 23. Cross Section of Magnetic Fields at 14 GHz

The electric and magnetic fields in the xz-plane are looked at next starting with the electric fields.



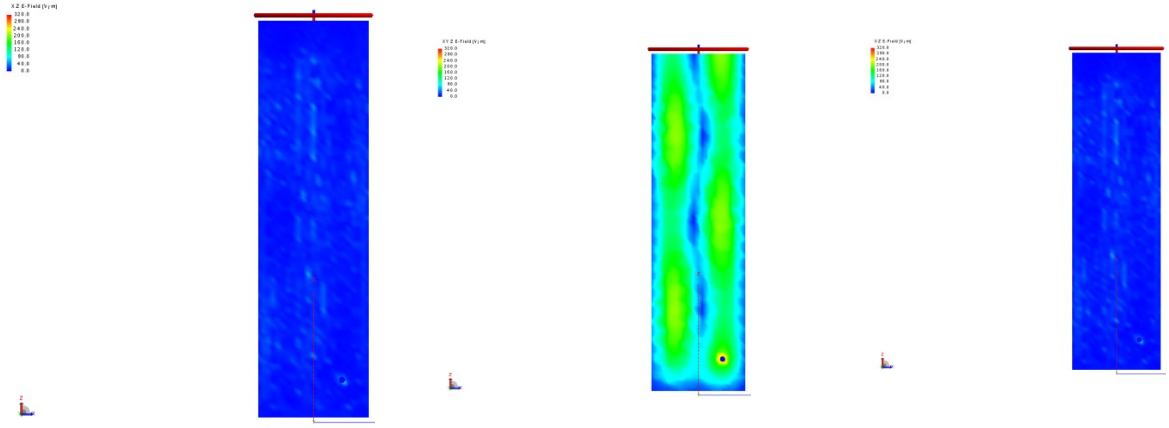
a) Ex Fields b) Ey Fields c) Ez Fields

Figure 24. XZ-Plane View of Electric Fields at 4 GHz



a) Ex Fields b) Ey Fields c) Ez Fields

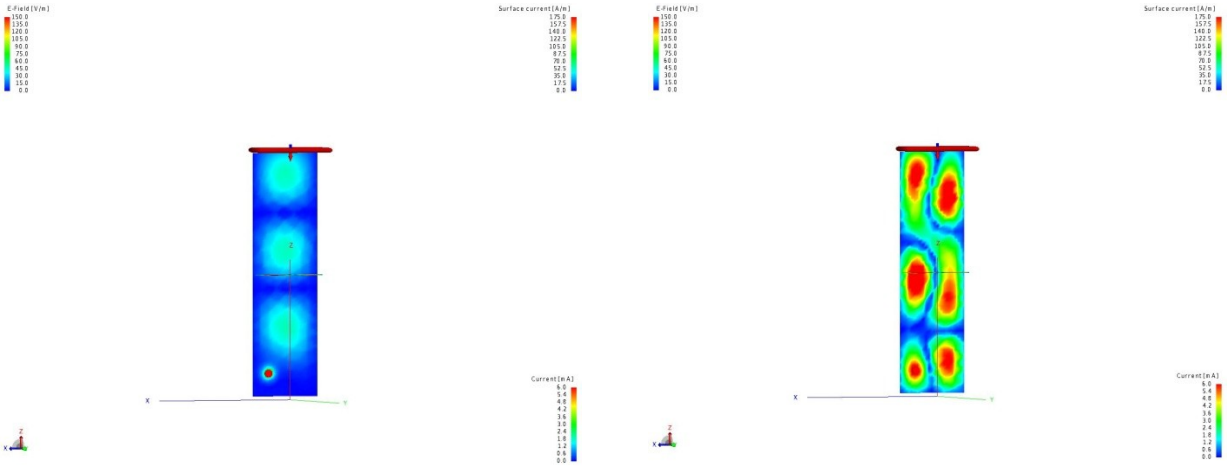
Figure 25. XZ-Plane View of Electric Fields at 9 GHz



a) Ex Fields b) Ey Fields c) Ez Fields

Figure 26. XZ-Plane View of Electric Fields at 14 GHz

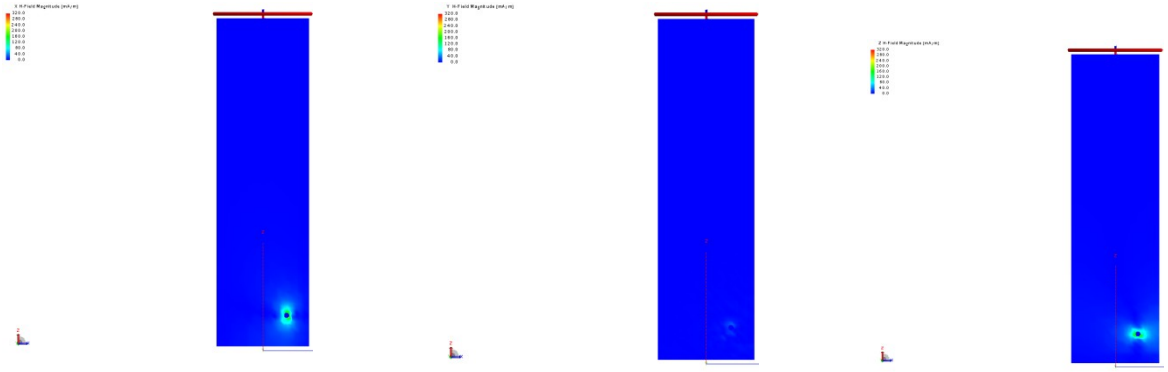
A look is taken the instantaneous fields as well to get a more clear idea of the field propagation.



a) 9 GHz b) 14 GHz

Figure 27. XZ-Plane Instantaneous Ey Fields

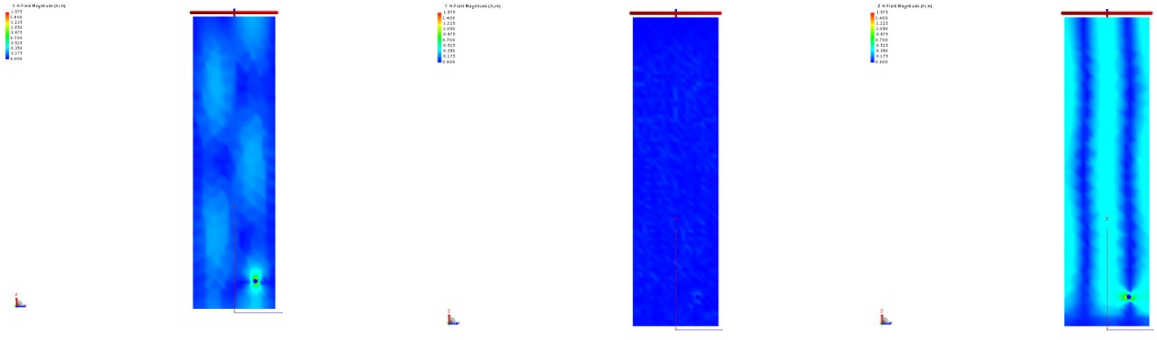
The magnetic fields are shown next.



a) Hx Fields b) Hy Fields c) Hz Fields

Figure 28. XZ-Plane View of Magnetic Fields at 4 GHz

As mentioned earlier because this frequency is below the cut off frequency no propagation of the fields occur as can also be noticed in figure 24.



a) Hx Fields b) Hy Fields c) Hz Fields

Figure 29. XZ-Plane View of Magnetic Fields at 14 GHz

For a clearer picture the instantaneous fields are looked at rather.



a) 9 GHz b) 14 GHz

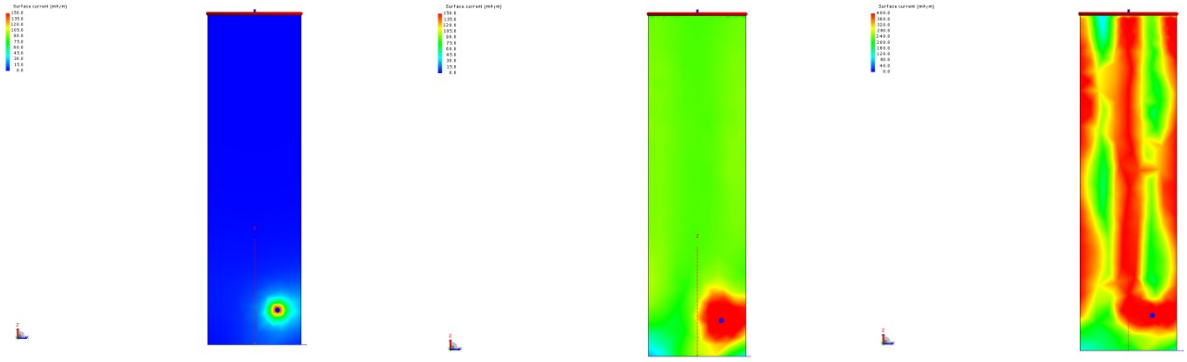
Figure 30. XZ-Plane Instantaneous Hx Fields



a) 9 GHz b) 14 GHz

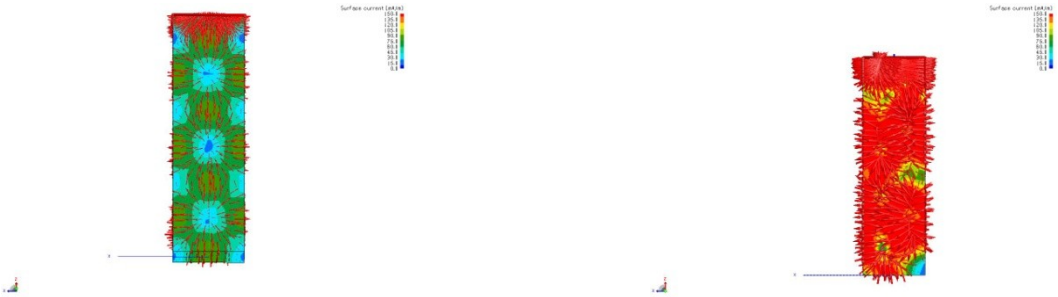
Figure 31. XZ-Plane Instantaneous Hz Fields

No Hy fields exist at any of the above frequencies. Lastly before concluding this section the surface current densities are looked at.



a) 4 GHz b) 9 GHz c) 14 GHz

Figure 32. Surface Current Densities on Broad Side Surface



a) 9 GHz b) 14 GHz

Figure 33. Instantaneous Surface Current Density at 9 GHz

The explanation following figure 16 applies here as well.