3D Lab Homework

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1 Task 1

The waveguide used in this simulation was a single waveguide with the dimensions ($x = 10\,\text{mm}, y = 40\,\text{mm}, z = 50\,\text{mm}$). The wave propagated in the z-direction. Some of the results of the simulation can be seen in Figure 1.

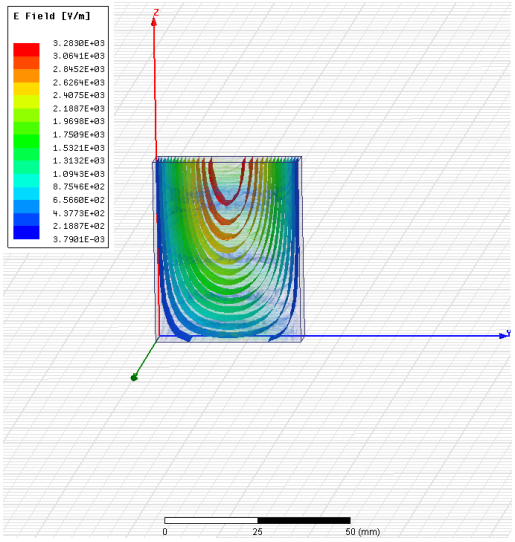
The cutoff frequency can be calculated using (1). For a hollow wave guide ($\mu_r \approx 1, \epsilon_r \approx 1$) with these dimensions ($a = 40\,\text{mm}$, $b = 10\,\text{mm}$) the theoretical cutoff frequency is 7.5 GHz. From Figure 1d it can be seen that the simulated cutoff frequency is also 7.5 GHz.

$$f_{\text{cutoff},m,n} = \frac{c}{2\sqrt{\mu_r \epsilon_r}} \sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2} \tag{1}$$

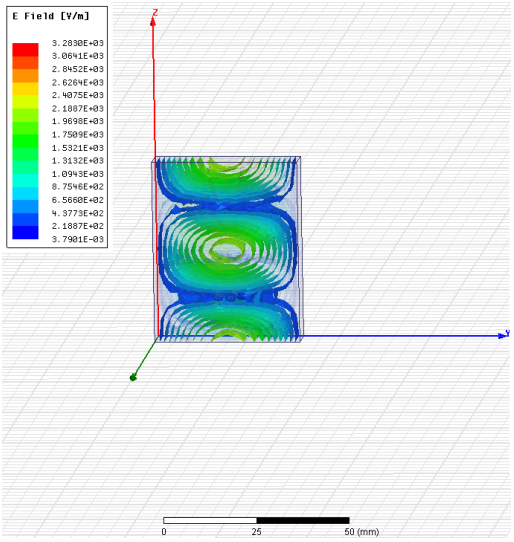
2 Task 2

In this task the wave guide was comprised of three sections. The first and the last section had the same dimensions as that which was used in Section 1 ($x = 10\,\text{mm}, y = 40\,\text{mm}, z = 50\,\text{mm}$) while the middle section had varying dimensions. The x-dimension ("height") was set to be the same as that of the first and last sections ($x = 10\,\text{mm}$). This design should essensially by a high-pass filter since a smaller waveguide would not allow lower frequencies to propagate through it.

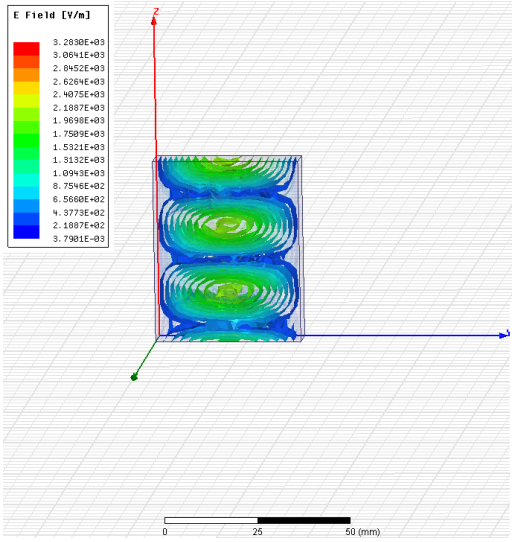
By comparing S_{21} for all of the different dimensions of the middle section (Figure 2d, Figure 3d, Figure 4d, Figure 5d, Figure 6d) it can be seen that the "width" of the middle section matters alot more than the "length" of the middle section. This seems reasonable given that the theoretical cutoff frequency depends on the width and height of the wave guide, not the length of it.



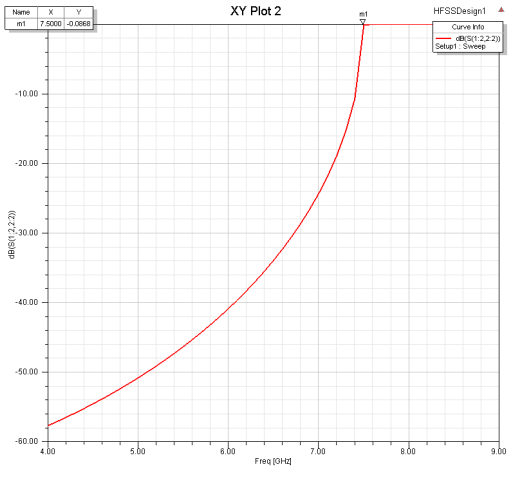
(a) The magnitude of the E-field at $f = 4\,\text{GHz}$.



(b) The magnitude of the E-field at $f = 7\,\text{GHz}$.



(c) The magnitude of the E-field at $f = 9\,\text{GHz}$.



(d) Output power of TE_{20} (S_{21}).

Figure 1: The figure shows the magnitude of the E-field and the S_{21} parameter for a waveguide with dimensions ($x = 10\,\text{mm}, y = 40\,\text{mm}, z = 50\,\text{mm}$).

2.1 Dimensions: y=10 mm, z=50 mm

It can be seen in Figure 2 that the cutoff frequency for this wave guide is above 9 GHz since the wave does not propagate through the middle section at this frequency.

2.2 Dimensions: y=30mm, z=50mm

It can be seen in Figure 3 that the cutoff frequency for this wave guide is just above 9 GHz although the wave manages to propagate through the middle section.

2.3 Dimensions: y=20 mm, z=10 mm

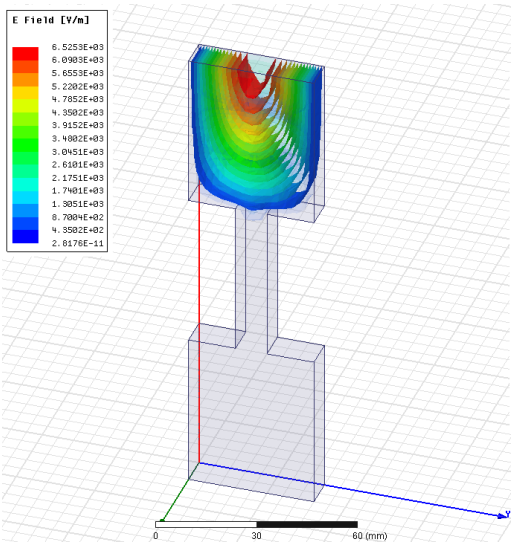
It can be seen in Figure 4 that the cutoff frequency for this wave guide is above 9 GHz although the wave manages to propagate through the middle section.

2.4 Dimensions: y=20 mm, z=30 mm

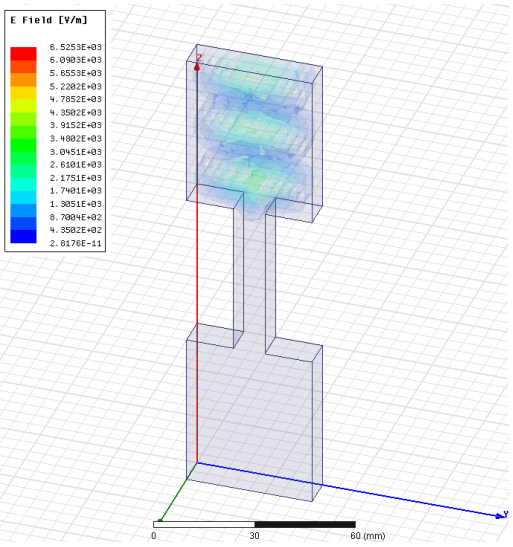
It can be seen in Figure 5 that the cutoff frequency for this wave guide is above 9 GHz although the wave manages to propagate through the middle section.

2.5 Dimensions: y=20 mm, z=50 mm

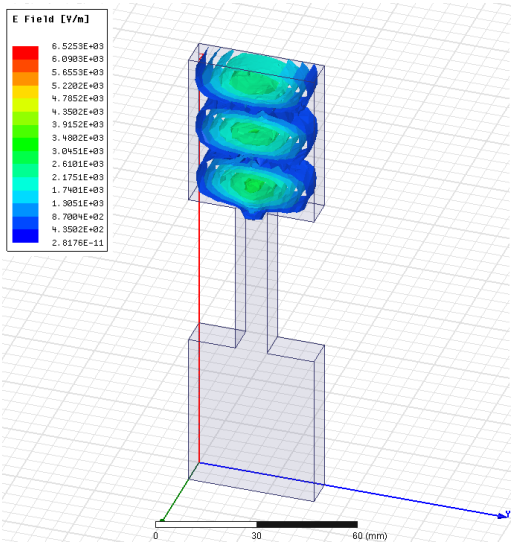
It can be seen in Figure 6 that the cutoff frequency for this wave guide is above 9 GHz although the wave manages to propagate through the middle section.



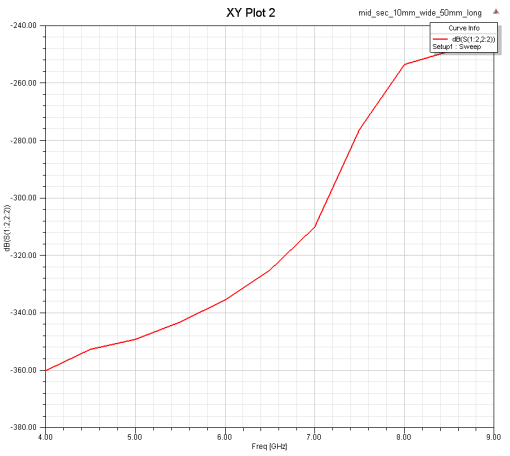
(a) The magnitude of the E-field at $f = 4\,\text{GHz}$.



(b) The magnitude of the E-field at $f = 7\,\text{GHz}$.

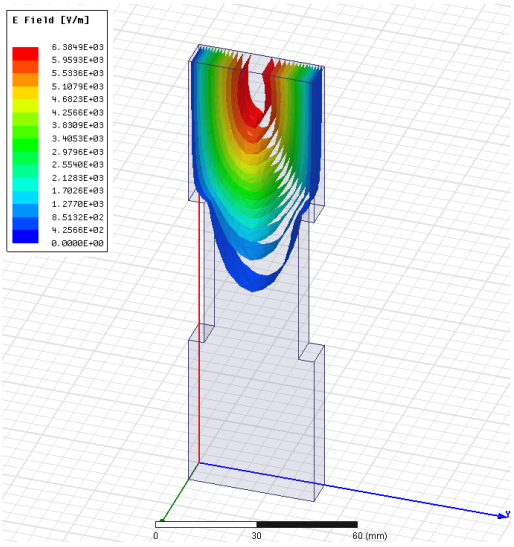


(c) The magnitude of the E-field at $f = 9\,\text{GHz}$.



(d) Output power of TE_{20} (S_{21}).

Figure 2: The figure shows the magnitude of the E-field and the S_{21} parameter for a waveguide when the middle section's dimensions were ($x = 10\,\text{mm}, y = 10\,\text{mm}, z = 50\,\text{mm}$).



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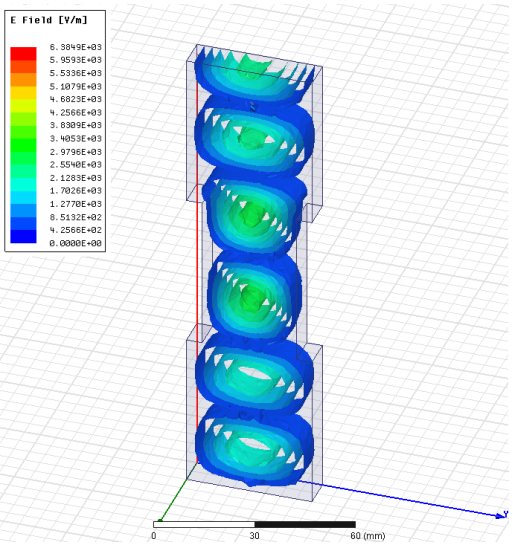
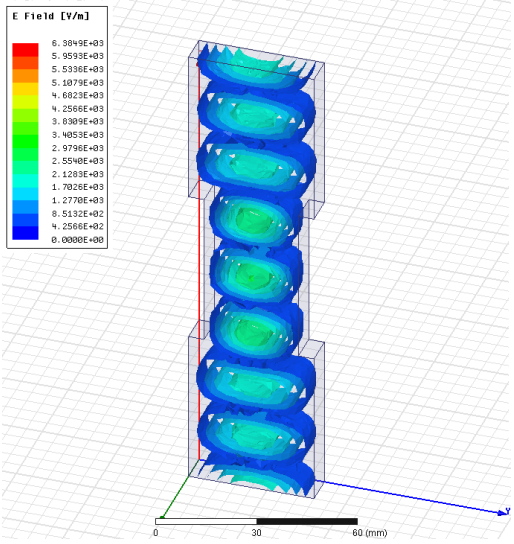


(b) The magnitude of the E-field at $f = 7\,\text{GHz}$.



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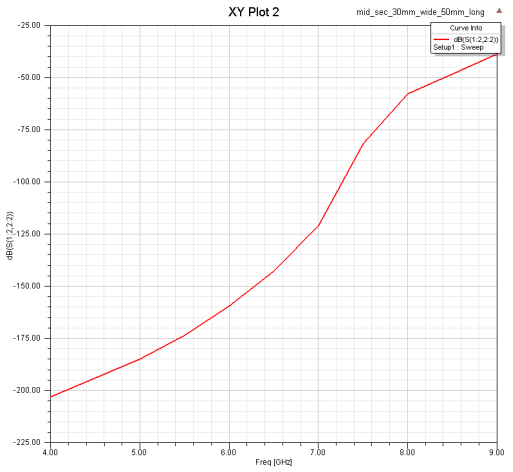
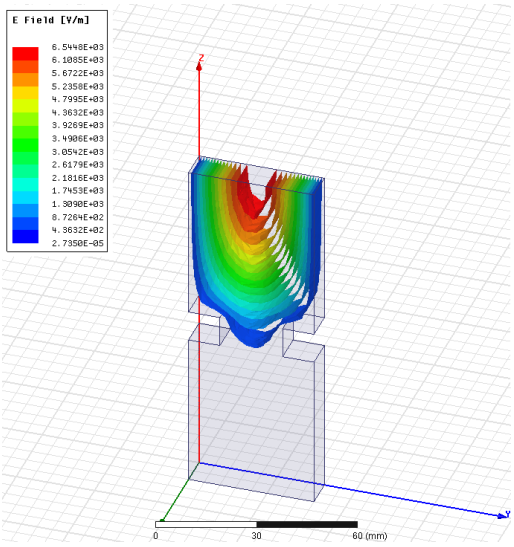


(d) Output power of TE_{20} (S_{21}).

Figure 3: The figure shows the magnitude of the E-field and the S_{21} parameter for a waveguide when the middle section's dimensions were ($x = 10\,\text{mm}, y = 30\,\text{mm}, z = 50\,\text{mm}$).



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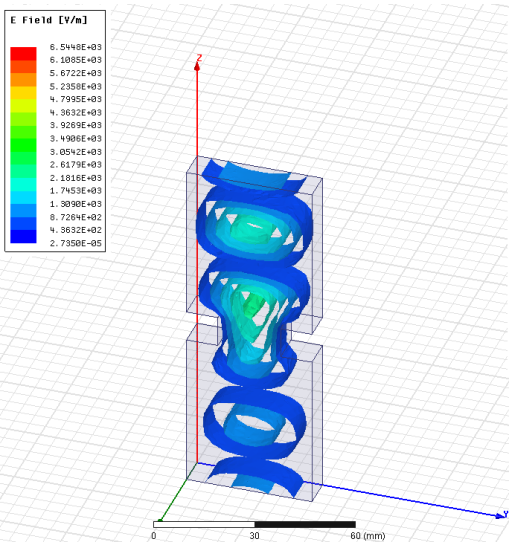
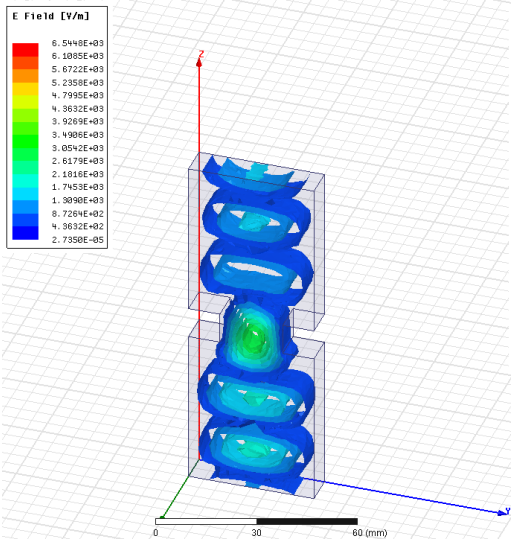
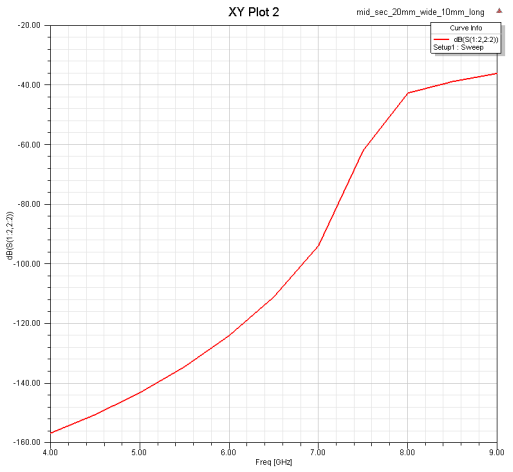


(b) The magnitude of the E-field at $f = 7\,\text{GHz}$.

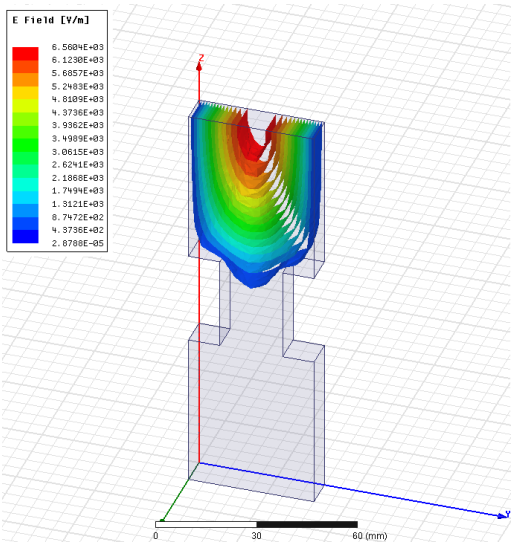


(c) The magnitude of the E-field at $f = 9\,\text{GHz}$.



(d) Output power of TE_{20} (S_{21}).

Figure 4: The figure shows the magnitude of the E-field and the S_{21} parameter for a waveguide when the middle section's dimensions were ($x = 10\,\text{mm}, y = 20\,\text{mm}, z = 10\,\text{mm}$).



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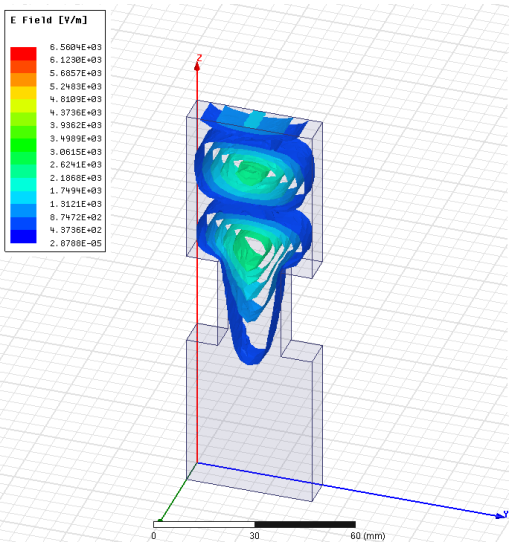
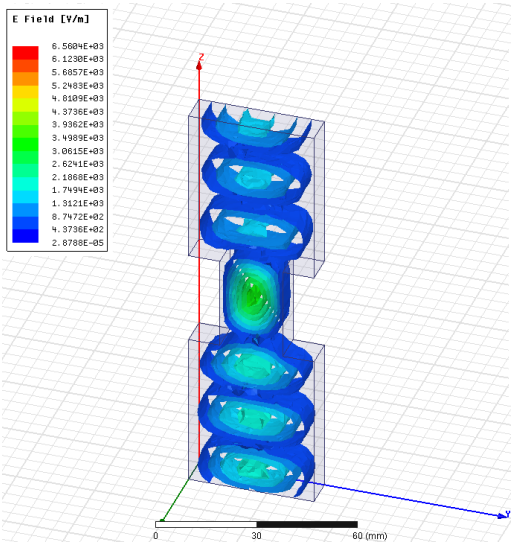


(b) The magnitude of the E-field at $f = 7\,\text{GHz}$.



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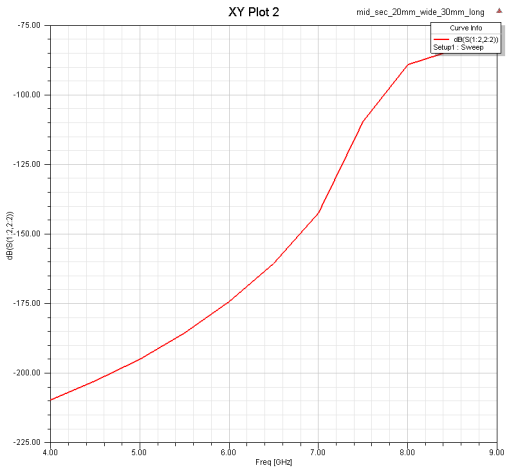

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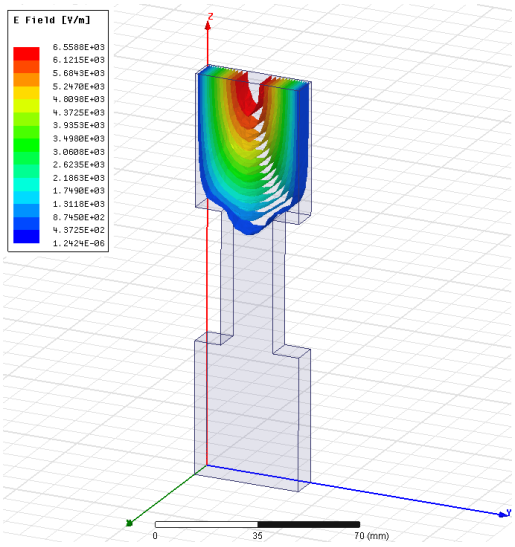

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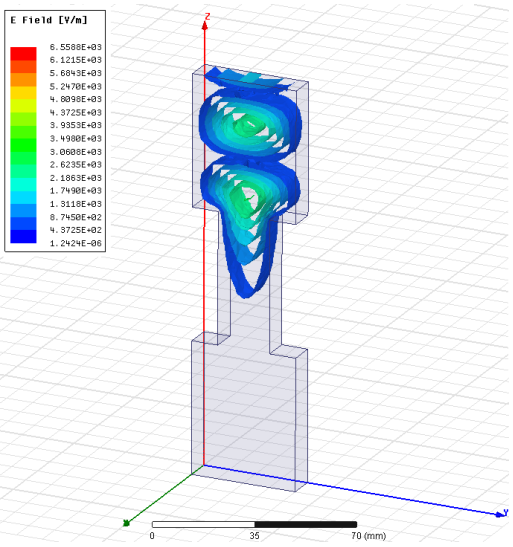

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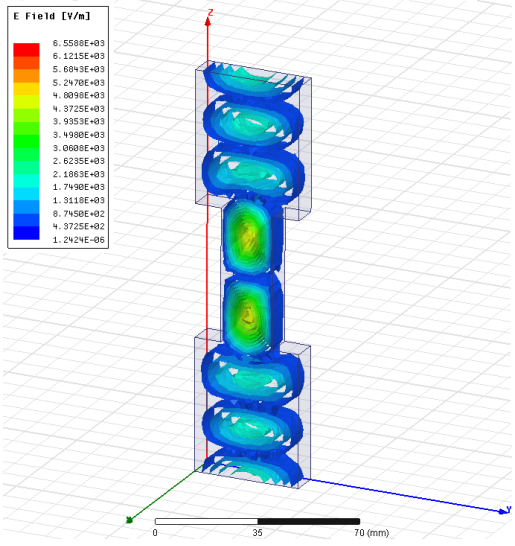

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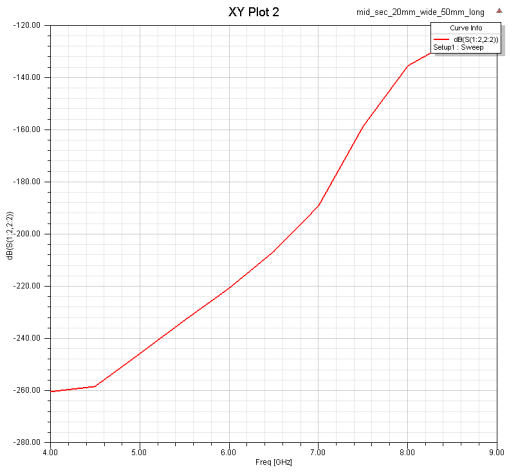

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