

Title: Developing an Inductive Stent to Accurately Detect the Occurrence of In- Stent Restenosis

Piyush Bahel

CSEF 2022

Construction of the Stent Design

Solid works, a CAD Modeling software, was utilized to construct the stent. I first created the outline of the stent as an unwrapped entity, which took the form of 2 sketched as seen in figures below. Figure 1, outlining the odd numbered layers, and, subsequently, in Figure 2, outlining the even numbered layers.

Figure 1:

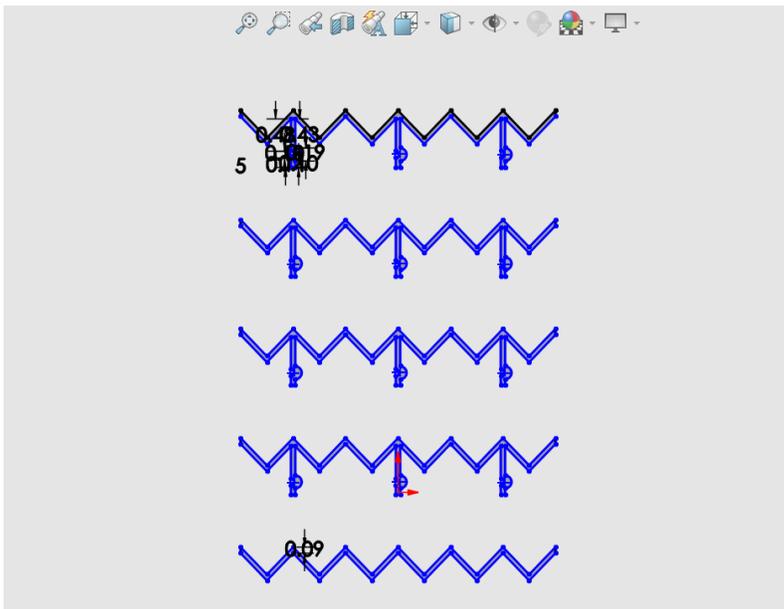
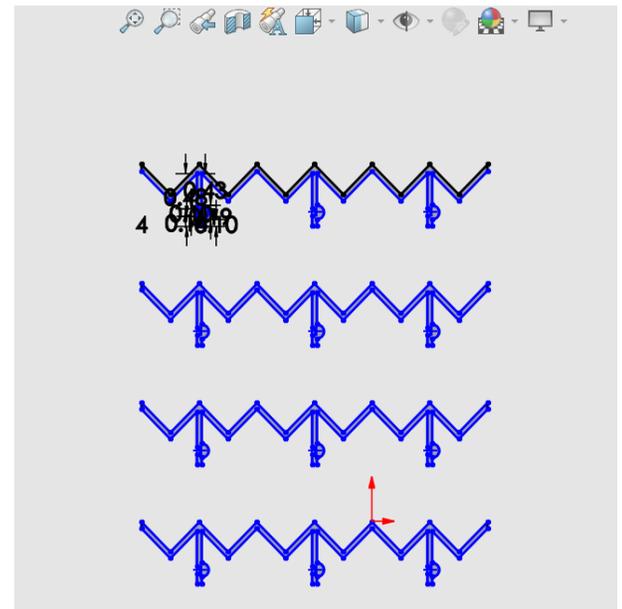
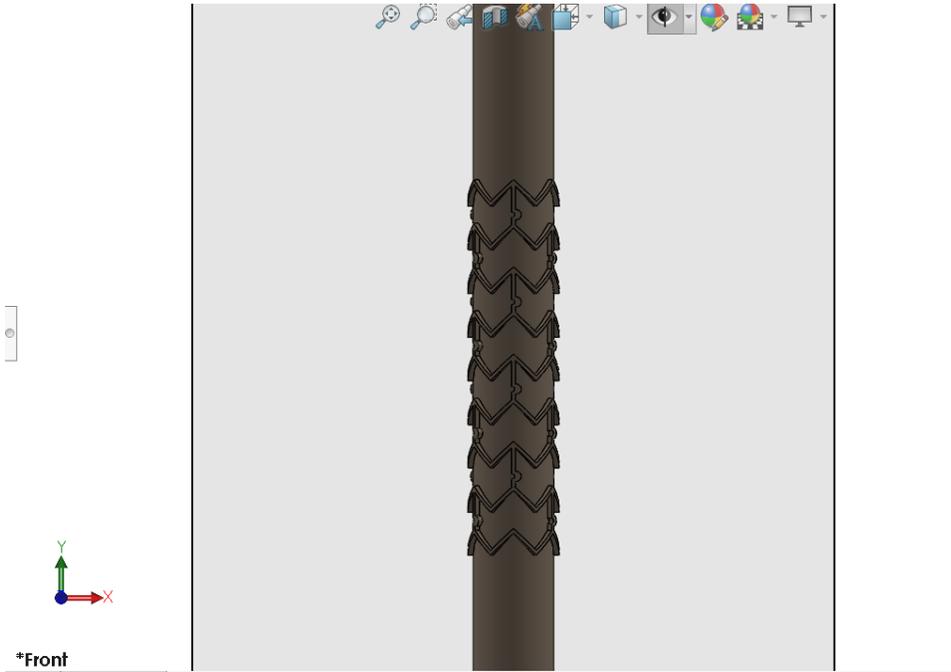


Figure 2:



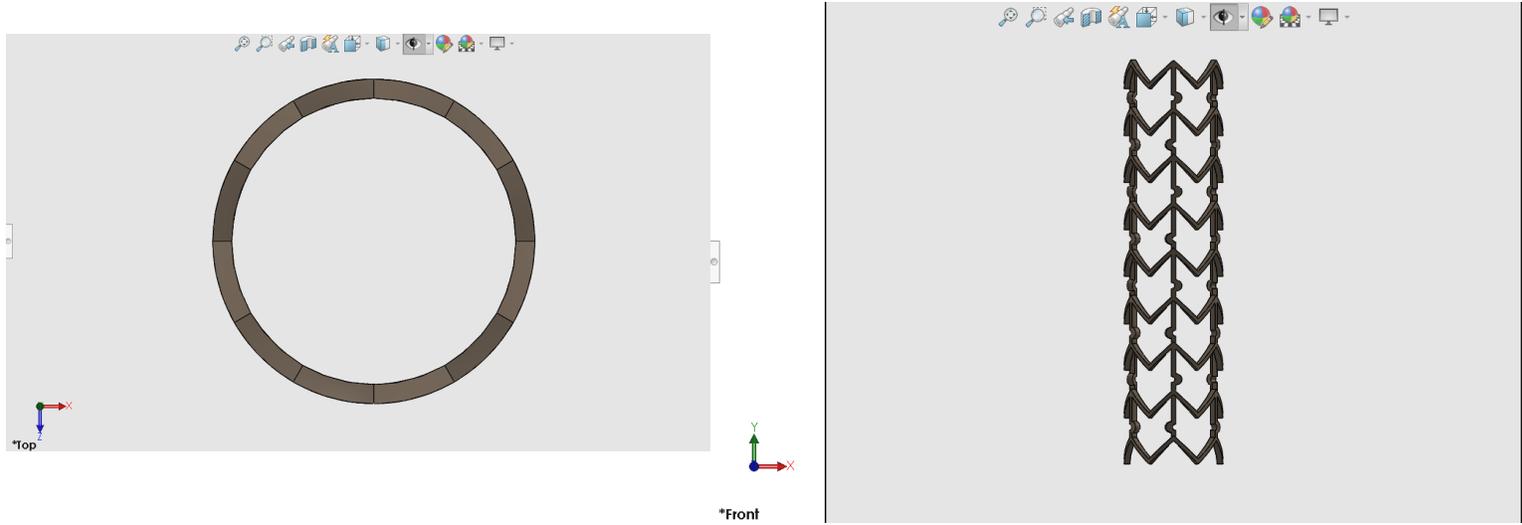
From here, a cylinder of radius 1.5 mm was constructed from a basic sketch of a circle with radius 1.5 mm and then extruded in both directions of 10 mm. Once extruded, the wrap feature was used on both sketches, selecting the newly created cylinder as its reference face. The result of this is illustrated in Figure 3.

Figure 3:



Here, the cut extrude tool was used to completely remove the cylinder and leave the stent as depicted in Figure 4.

Figure 4:



Simulations:

To examine how blood flow impacted the stent design in a static simulation, I used a flow simulation to simulate the flow trajectories and flow pressure and then exported those results into a static simulation for further studies.

Flow Simulation:

To make the flow simulation, the solidworks add-in was installed and then the flow simulation wizard was brought up.

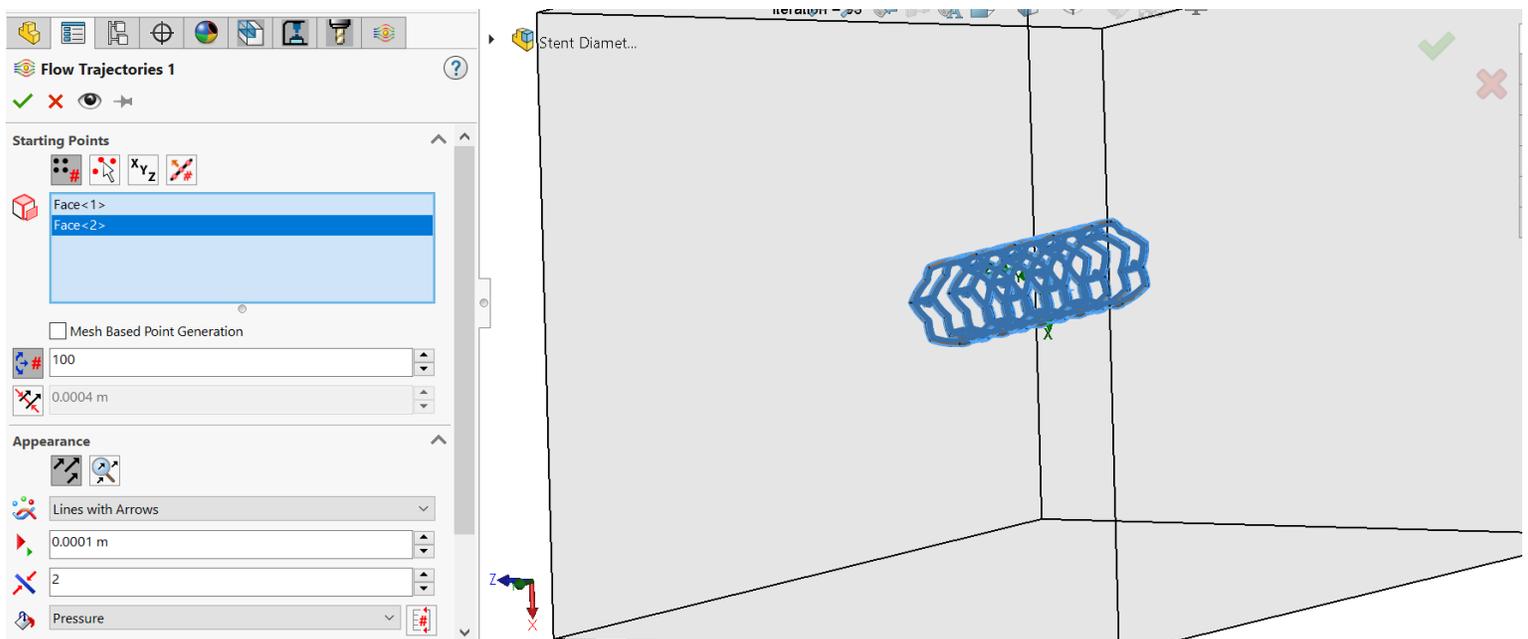
The inputs for the flow simulation wizard are as follows: for the analysis type, external was chosen, for the fluid, blood was chosen from the Non-Newtonian Liquids dropdown, for the temperature, 310.15 K was used, and the velocity in the Y-direction was -0.66 m/s.

With these inputs added, the simulation was run. From the results dropdown, I clicked on the flow trajectories to see how they would show. To set up the flow trajectory, the starting points were found when hovering over the stent. Two faces had to be selected in order to fully cover the stent.

In regards to appearance, 100 was inputted as the number of points, lines with arrows were chosen to show the trajectory and color was in accordance with pressure.

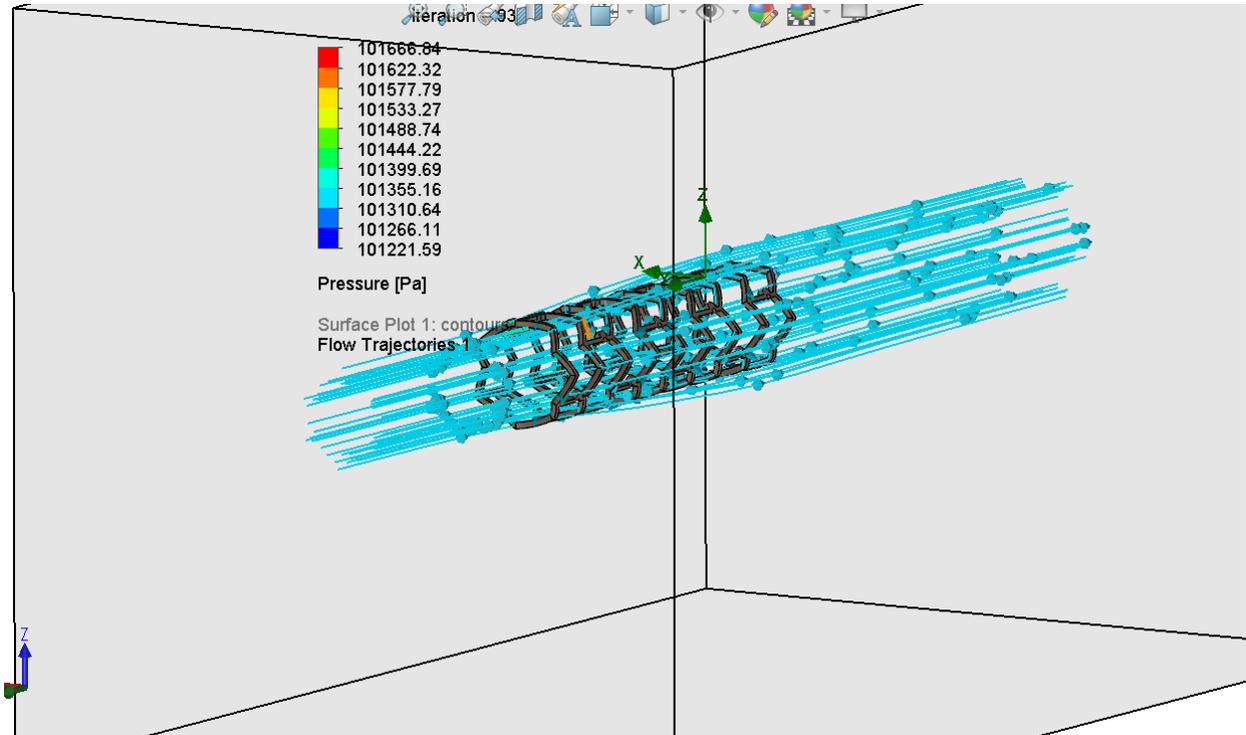
The setup is shown in Figure 5.

Figure 5:



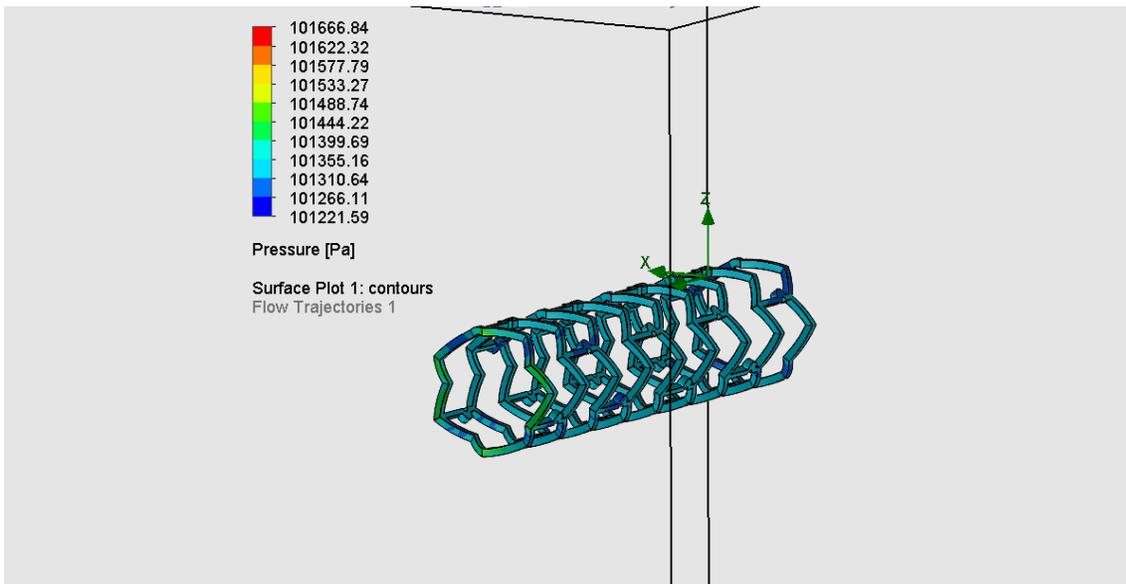
Once the setup was confirmed the results were shown and are in Figure 6.

Figure 6:



Continuing with the flow simulation, I inserted a surface plot and selected to model pressure as contours. The results are shown in Figure 7.

Figure 7:

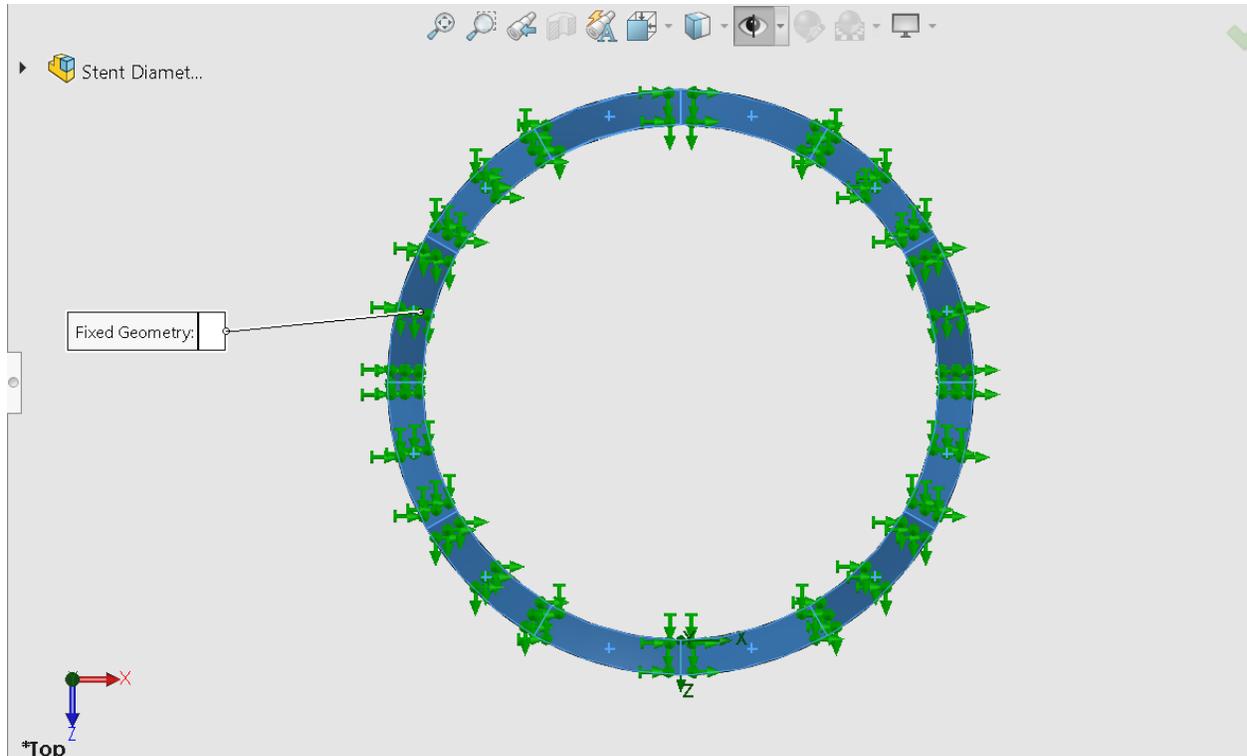


Static Simulation:

Once these were completed, I exported the flow simulation results to a static simulation. This was done by going to flow simulation → tools → export results to simulation.

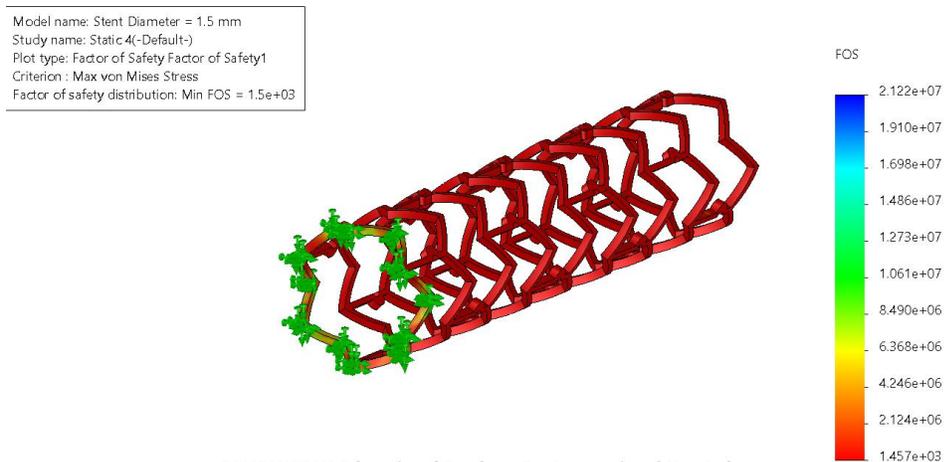
Before running the static simulation, fixtures were required. Therefore, I fixed the stent along the top as shown in Figure 8.

Figure 8:



Now it was time to add a material. As there was no nitinol material on Solidworks, the custom material feature was used. Once added, the simulation was run and the Factor of Safety (FOS) plot was defined. This is depicted in Figure 9.

Figure 9:



The FOS plot shows the structural stability of the model. Since FOS is calculated as the tensile yield strength divided by the von mises stress, if the minimum FOS, where von mises stress is greatest, is greater than 1, the structure shows stability as the material is stronger than the force it experiences. Therefore, this stent is structurally stable as its minimum FOS is greater than 1.

Ansys Electronics Desktop Simulation Setup:

The purpose of these simulations was to verify the magnetic field testing of the transmitter that is going to be used for the inductive stent's medical application. This was done by creating the transmitter receiver setup and then optimizing it by changing the number of connectors and rings and running the same simulation in order to see which simulation has the strongest magnetic field.

Creating the models:

To design the simulations for Ansys Electronics Desktop, another stent was created with a diameter of 5 mm. The 3 mm stent will act as the receiver of the simulation and the 5 mm stent will be the transmitter of the simulation.

To perform each scenario, 4 constructs were made for each simulation. These constructs were the 3 mm stent with thickness 0.1 mm and 0.15 mm and the 5 mm stent with thickness 0.1 mm and 0.15 mm. This is because, in each simulation both the transmitter and the receiver are surrounded with a layer of gold of 0.05 mm. To create this layer within Ansys Electronics Desktop, the inner layer (thickness of 0.1 mm) and the outer layer (thickness of 0.15 mm) were combined using the subtract feature. This created a surrounding layer of 0.05 mm over the inner layer. The result is shown in Figure 10 for the first simulation. This layer was assigned the material gold. The inner layer was assigned the material stainless steel as properties of nitinol were unknown for this software. This process was done for both the 3 mm stent and the 5 mm stent and the two stents were separated by a distance of 11 mm. The result is shown in Figure 4 for the first simulation of 1 ring and 3 connectors.

Figure 10:

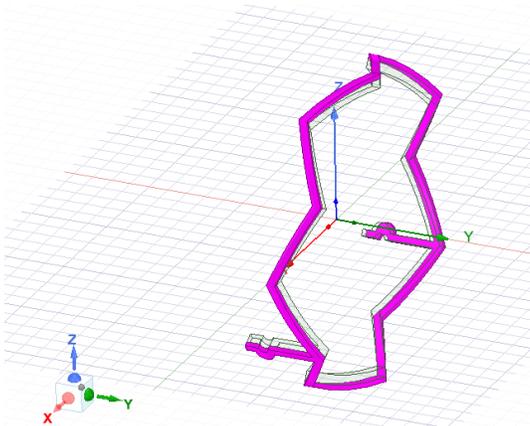
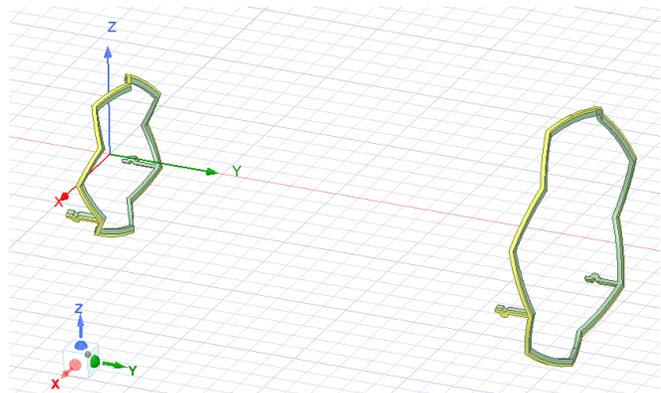
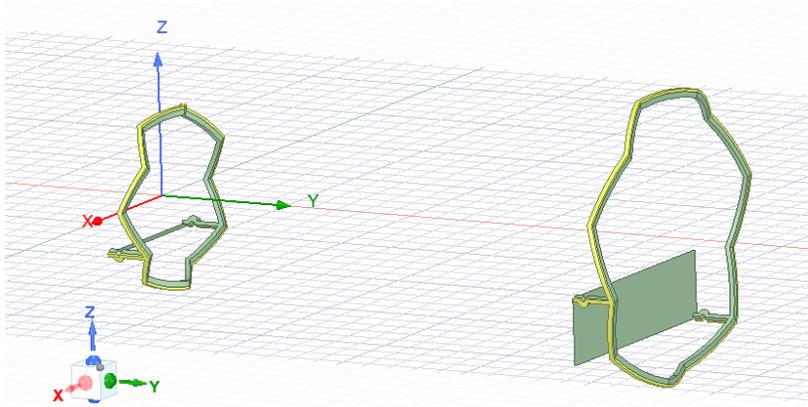


Figure 11:



To add the capacitors to the stents, sheets were added to the connectors of the stents and then assigned impedance values of 50 ohms. This was done by creating a rectangular sheet with no material from one connector to another. Before creating the rectangles, within the properties tab, analysis was chosen and an advanced solution setup was created with a frequency of 13.56 MHz. From here a frequency sweep was added to the setup with a range of 6.89 MHz to 20.34 MHz. Each rectangle was assigned a boundary of Perfect E to ensure the connection from one connector to another. Then each rectangle was assigned an excitation of a lumped port with a value of 50 ohms. The excitation was defined using a line from the midpoint of one side of the rectangle to another. The results are shown in Figure 5 below for the first simulation.

Figure 5:



Once the design of the transmitter and receiver were created a medium needed to be formed for the simulation to take place. To create a medium, a rectangular prism was created from the origin with x, y, and z lengths being 500, 500, and 500 respectively. The rectangular prism was then assigned a starting point of -250, -250, and -250 and given the material air. The design was then validated and simulated using the analyze all function.

Once simulated, the magnetic field was plotted for each simulation. The strongest magnetic field was seen in the simulation with 5 rings and 3 connectors. The result is shown in Figure 12.

Figure 12:

