TRAVELING WAVE TUBE OUTPUT WINDOW MODEL

(IMPEDANCE MATCHING PROBLEM)

Team Members

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Project Overview

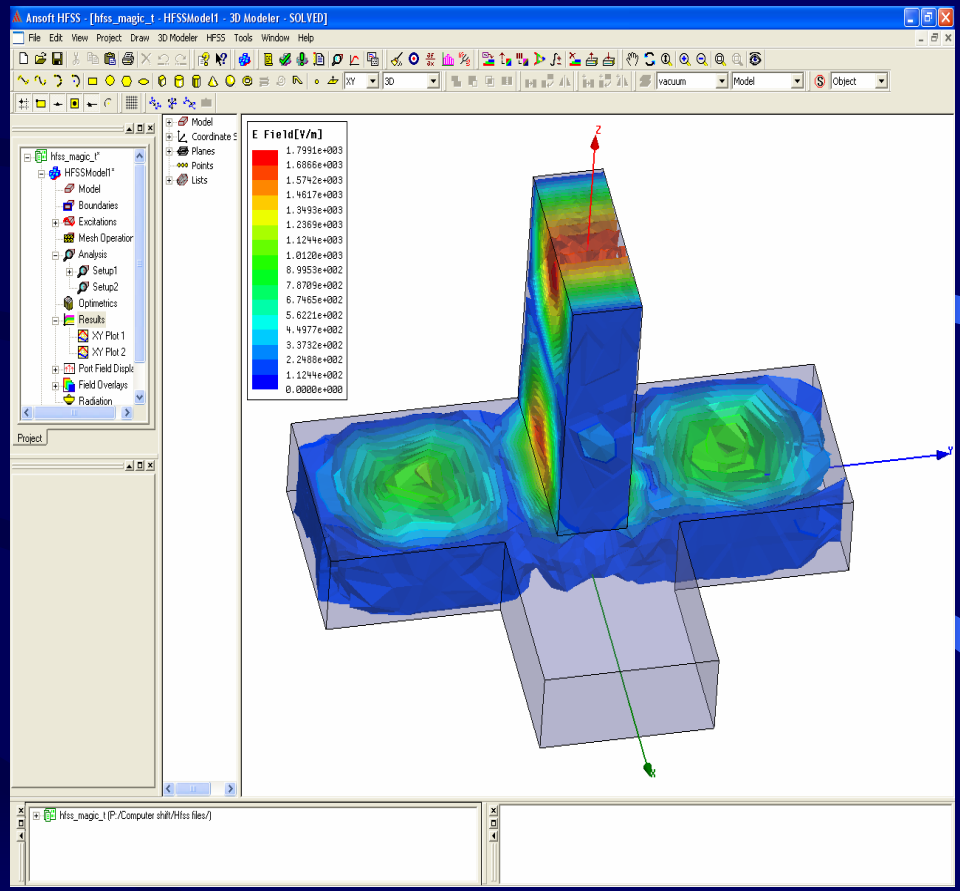
- Background of HFSS & TWT
- Modeling Process
- Discoveries / Results
- Conclusion

Goal

Figure out how to model an output circuit in HFSS and set a Standard Procedure for future simulation process.

HFSS Background

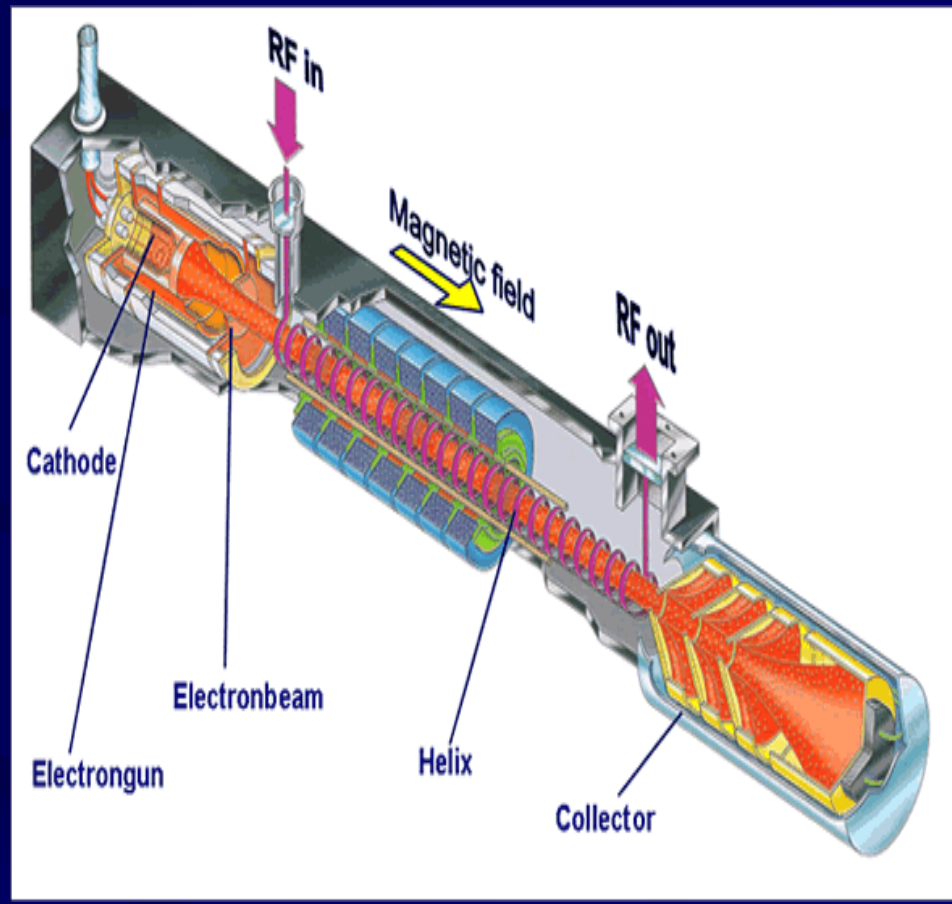
- 3D EM Simulation Software Tool for RF, Wireless, Packaging and Optoelectronic Design
- Used for modeling High speed PCB, Package, IC, Antenna, Array Design along with RF and Microwave component design.



HFSS Interface

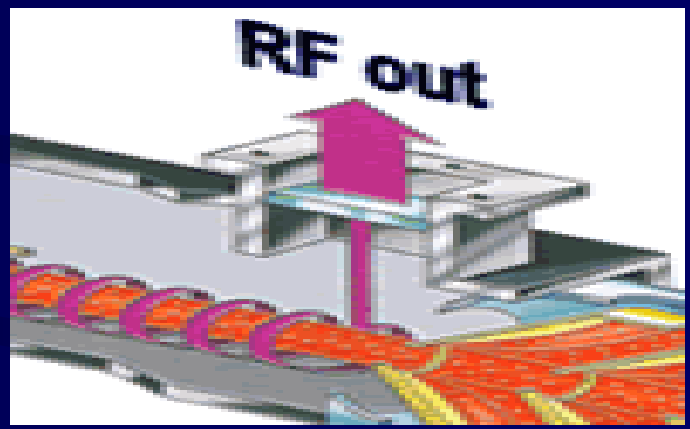
Traveling Wave Tube (TWT) Overview

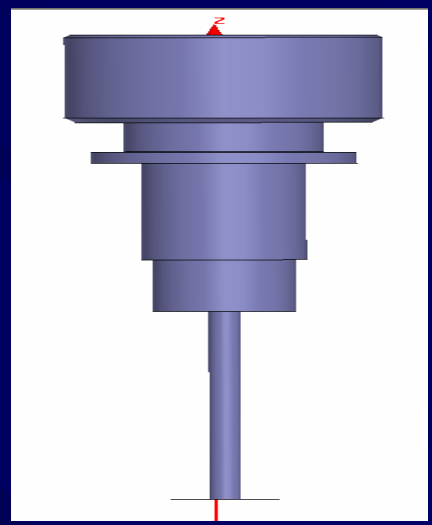
- High Frequency Wideband Amplifier
- Output Power Ranges from Watt-Mega Watts
- Used as final amplifiers In nearly all warfare and satellite communication systems.



The Output Window

- It is a transmission line that matches the impedance from the vacuum to a coax.
- A bad match can cause reflections going back into the tube which can damage the tube itself.

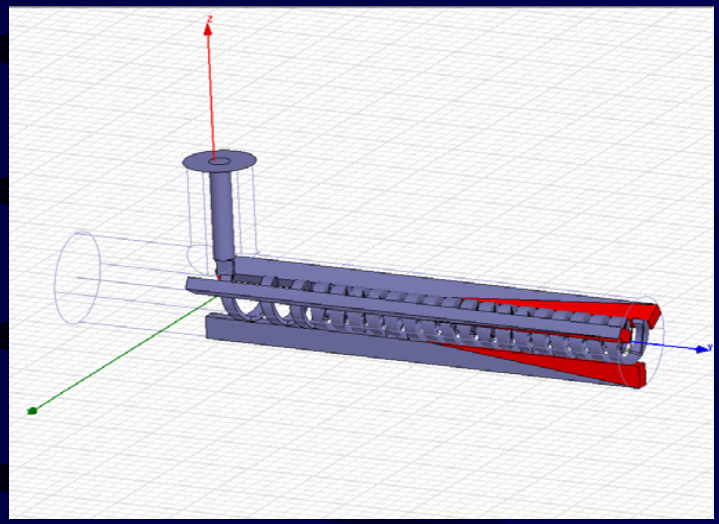




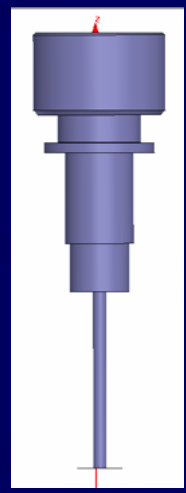
Project Iterations and Learning Aspects

- Capabilities of HFSS were unknown in the beginning.
- Memory Issues.
- No one had attempted to model the whole output circuit before

Pieces Of Our Model

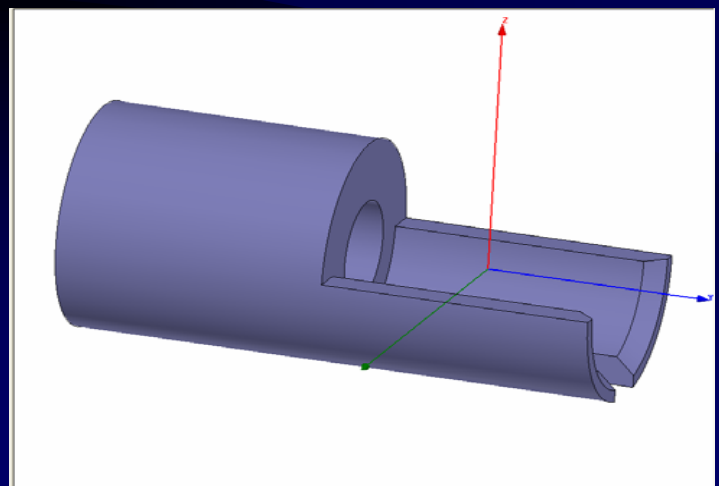


Helix circuit only

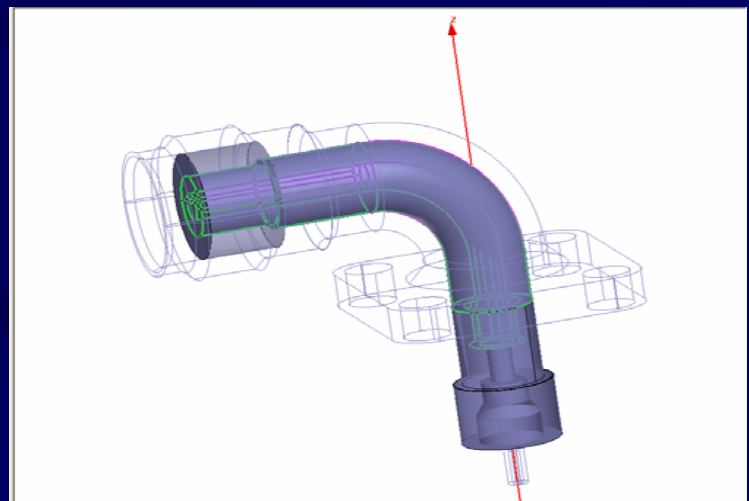


Dome Window

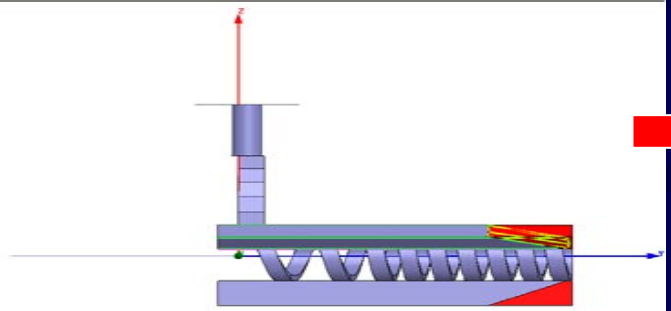
Matching Fingers



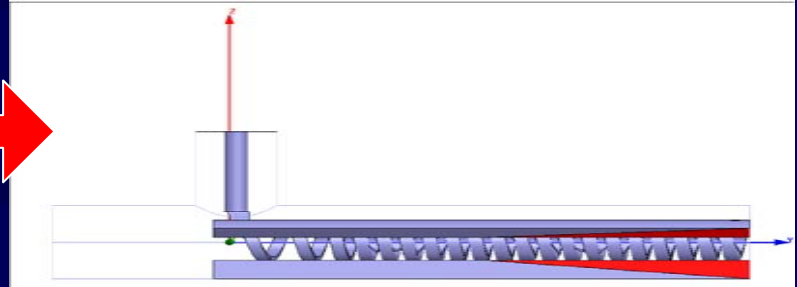
Coaxial Connector



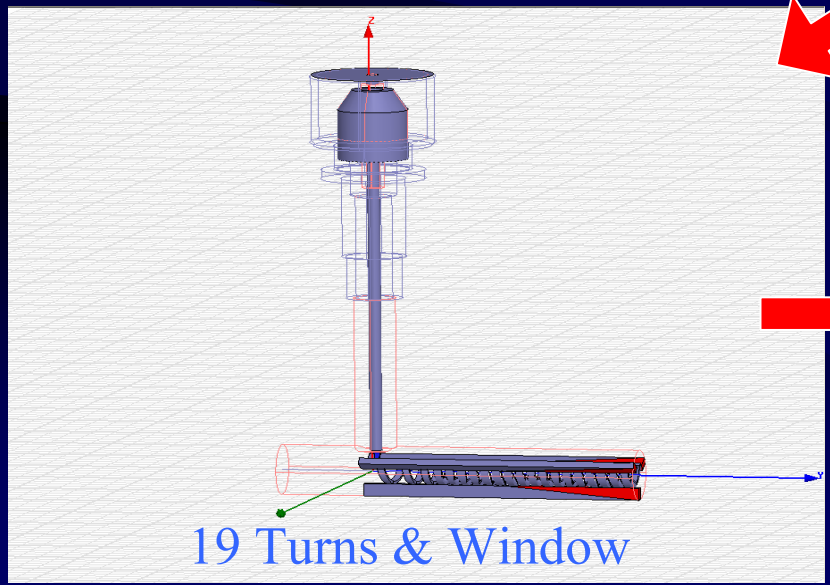
Modeling Process



9 Turns-Loss away from Helix



19 Turns-Loss close to Helix

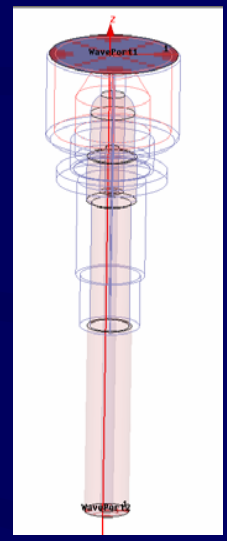


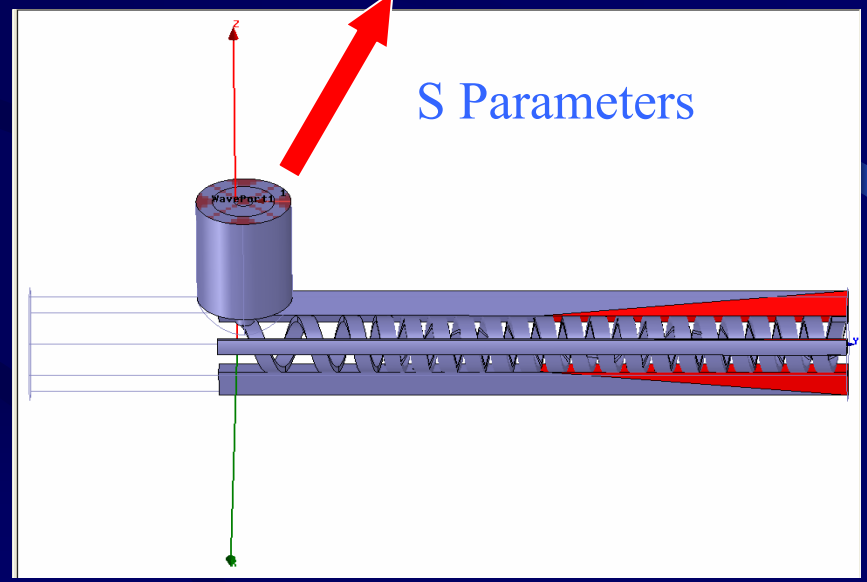
19 Turns & Window

19 Turns, Window & Coax

Initial Plan

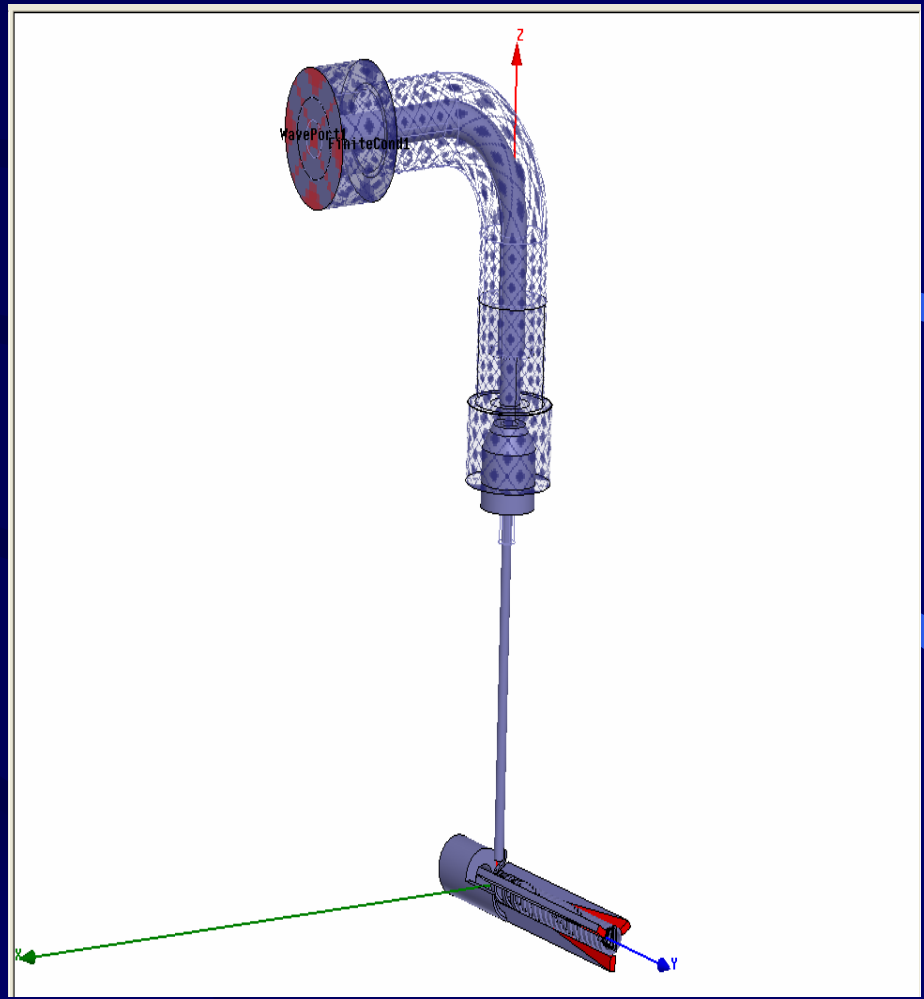
- Solve all the pieces separately for their VSWR.
- Combine solutions to solve the whole problem.
- Realized that waveports could not be assigned with S parameter values.





Actual Process

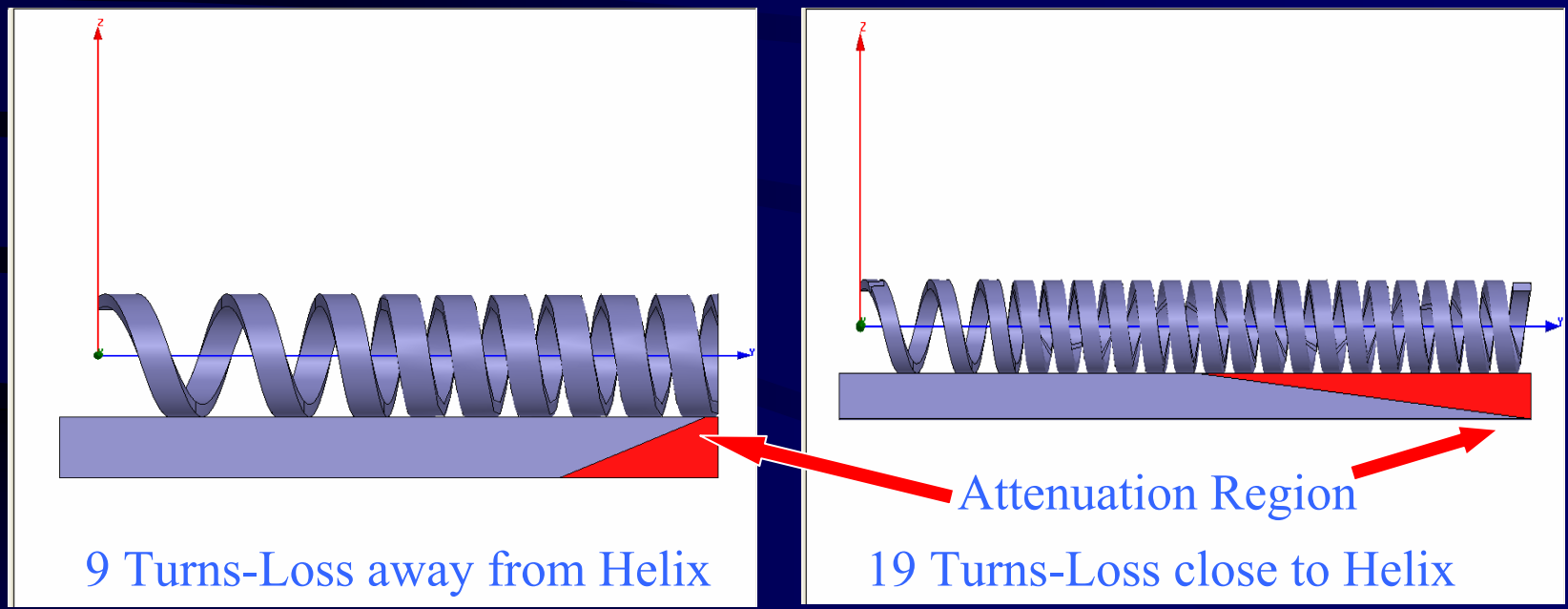
- Learned the traits of HFSS.
- One model piece was added at a time.
- Finally the whole circuit was solved in HFSS.



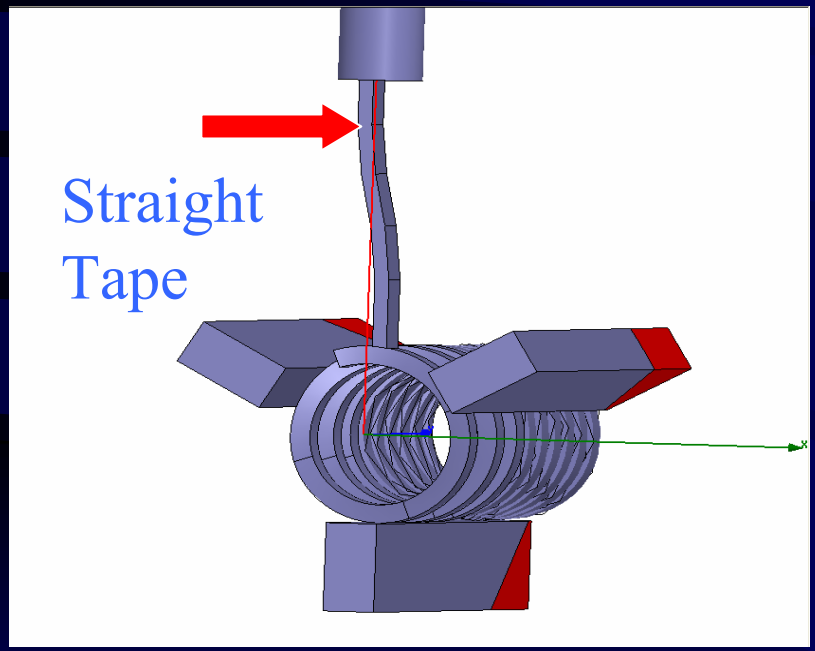
Critical Modeling Decisions

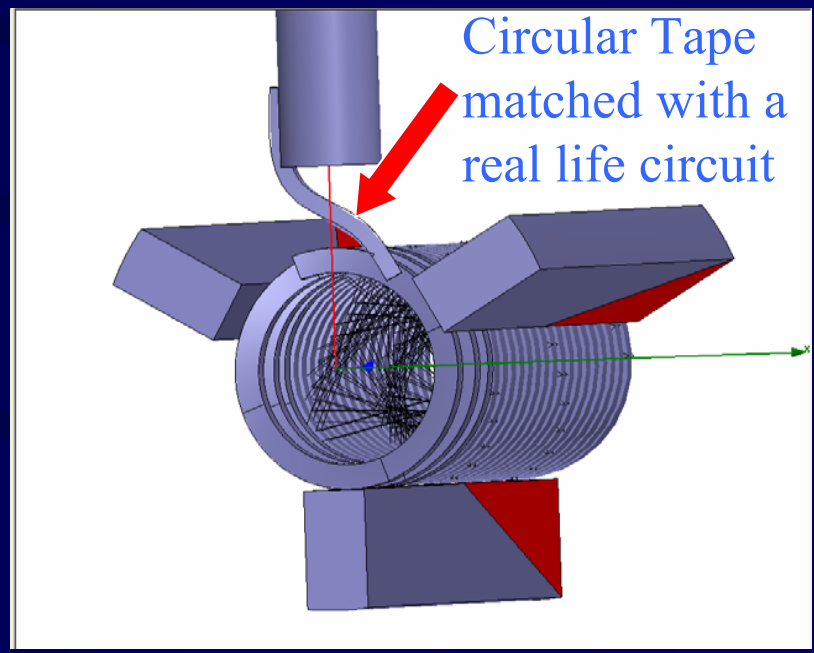
- How to introduce attenuation in the circuit to make it into a one port device.
- Tape geometry.
- Inclusion of Matching Fingers.
- Waveguide or Coaxial connector.

Introducing the Attenuation

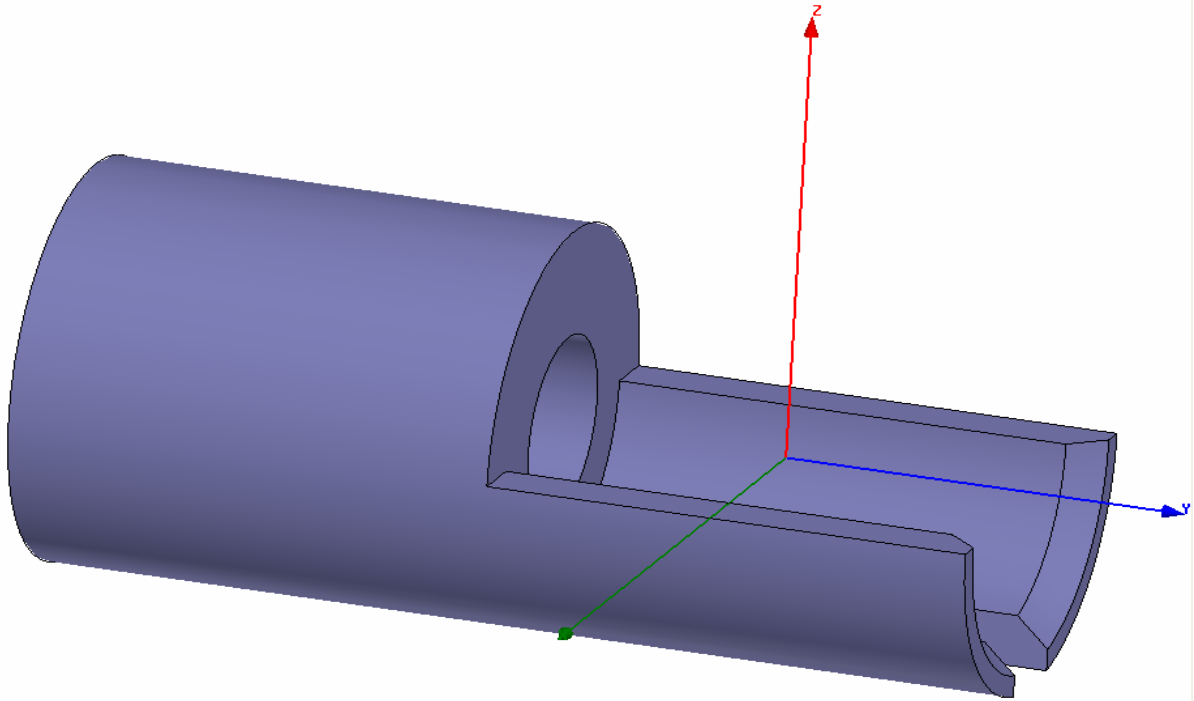


Tape Geometry



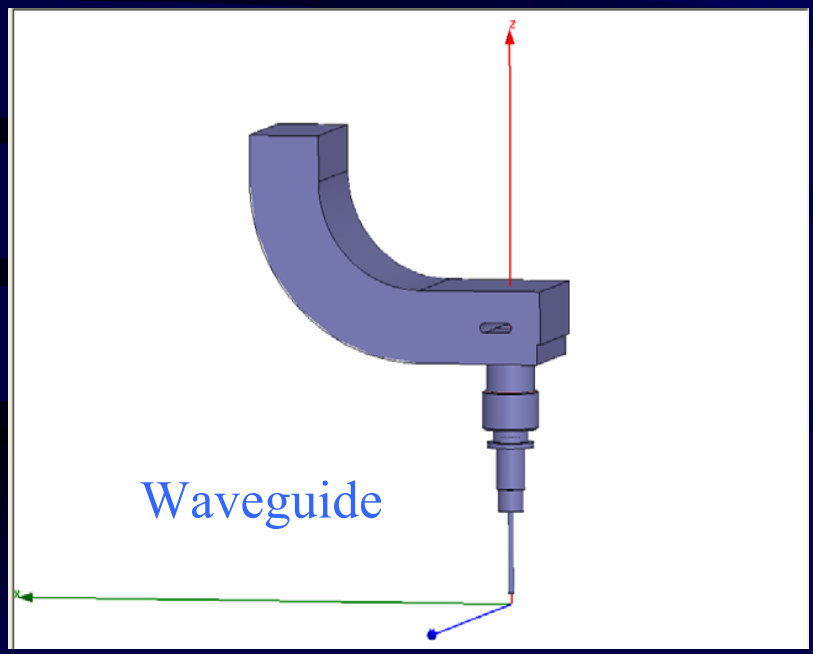


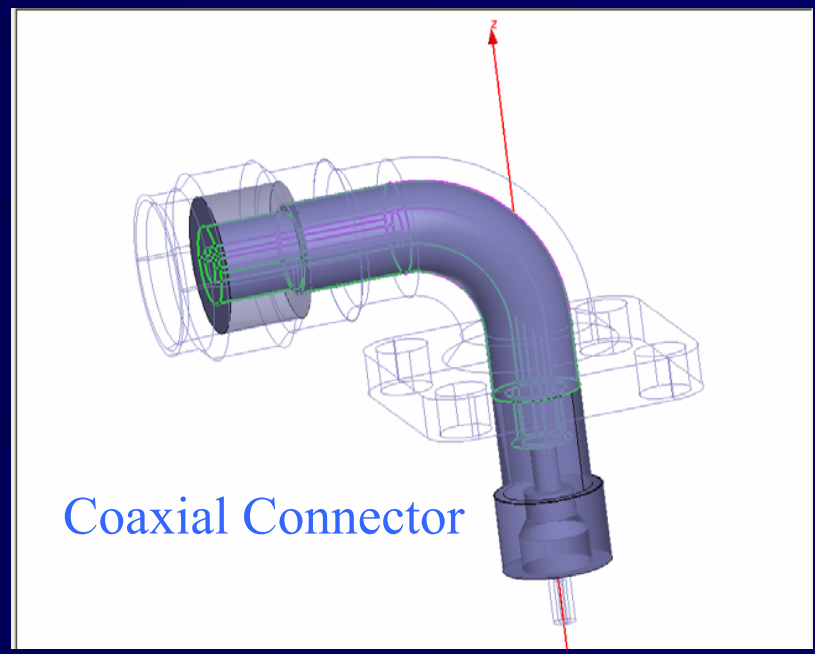
Matching Fingers



Used In Real Circuits To Tune The Impedance Match

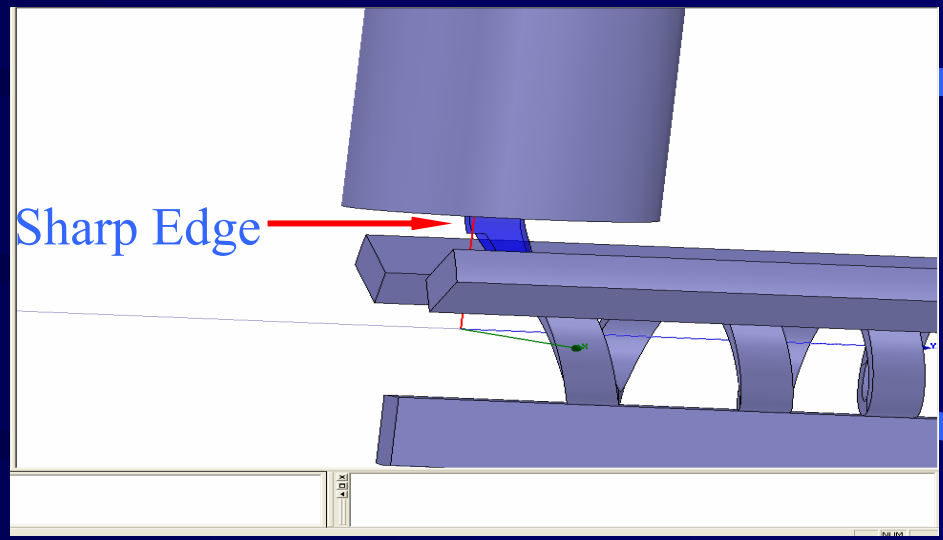
Waveguide or Coaxial Connector

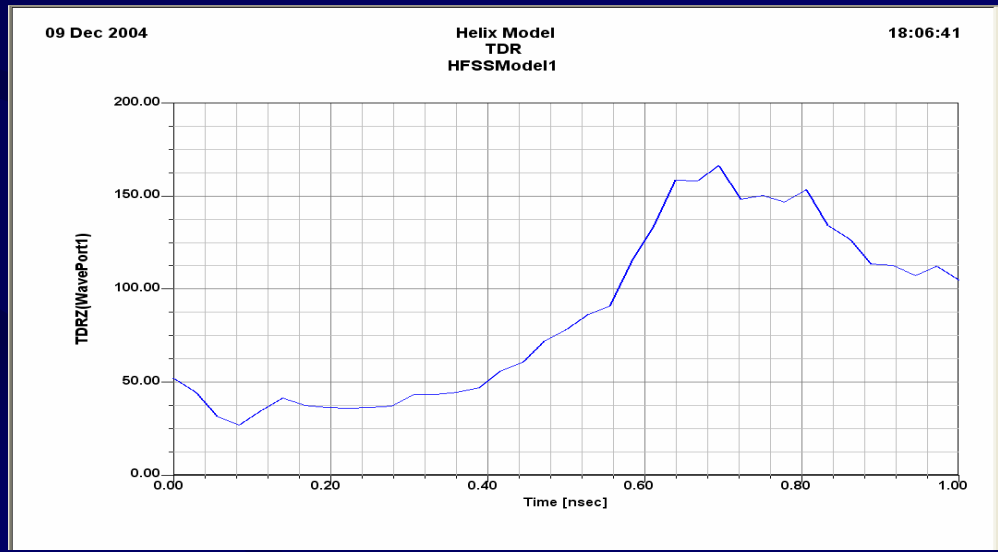




Discoveries

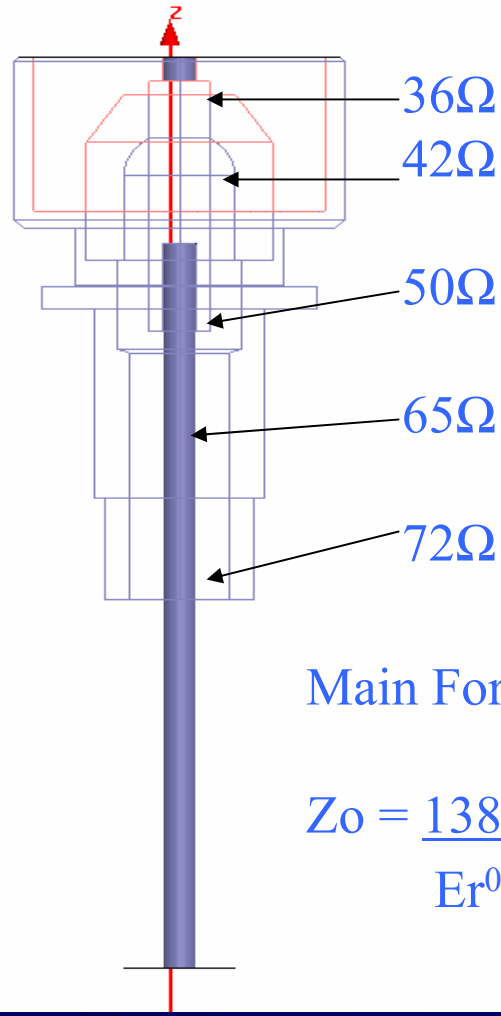
- Small sharp edges were disliked by HFSS and cause the program to run out of memory.
- Time Domain Reflectometry (TDR).





Discoveries Contd.

- Import models from other programs.
- Fault in the original window design.
- Very top of the window should be 50 Ω

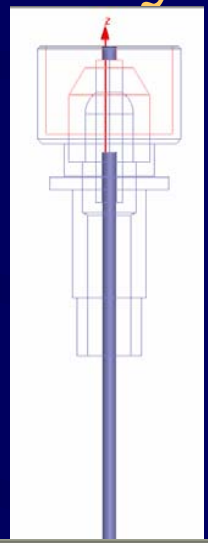


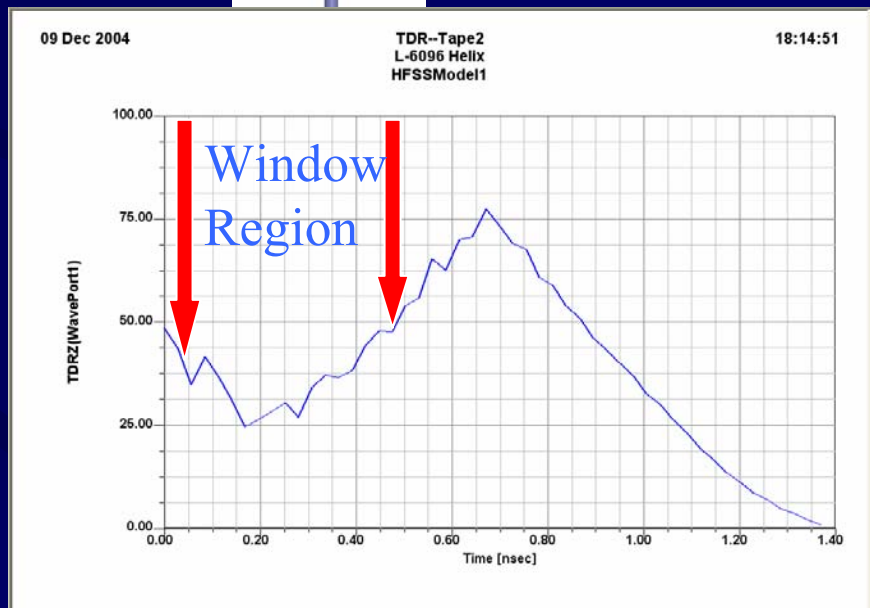
Main Formula

$$Zo = \frac{138\log(D/d)}{Er^{0.5}}$$

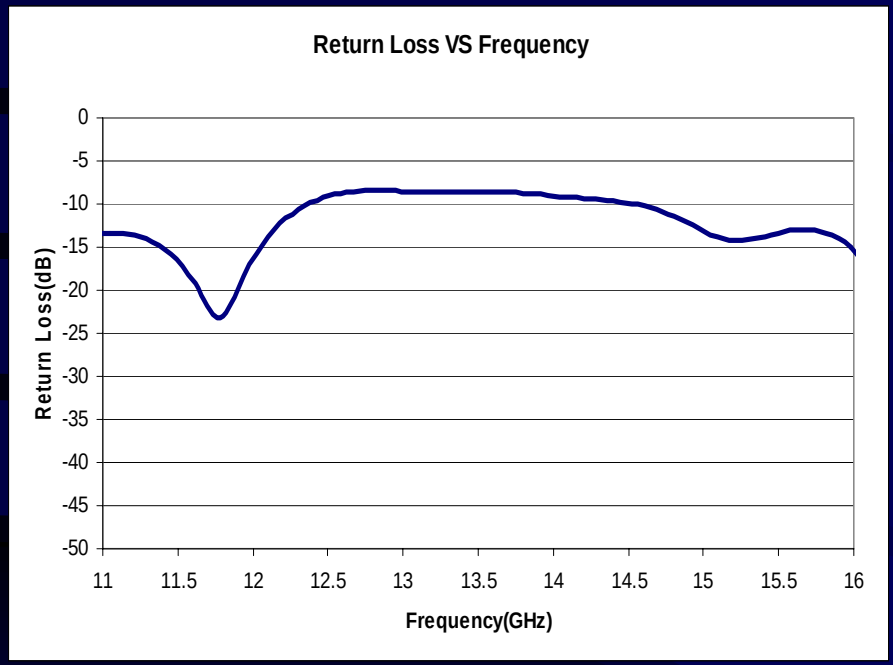
Confirmed Original Fault By TDR

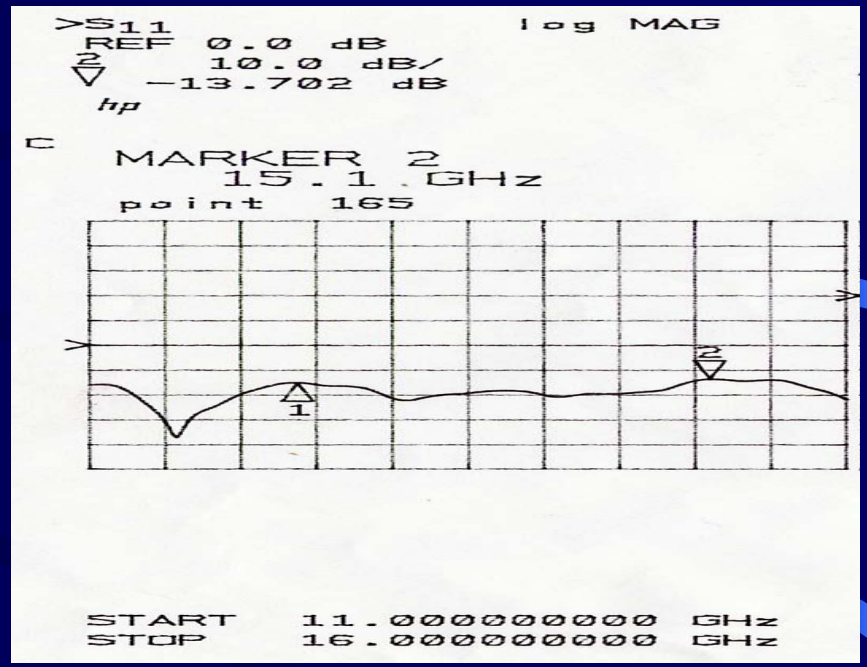
- TDR gives us a plot of Impedance of the circuit versus time.
- Calculations were confirmed by the TDR plot of the circuit.





Output Comparison





- The wave characteristics are the same
- The magnitude is comparably at the same level

Conclusion

- Figured out how to model the Output Circuit successfully.
- Findings will be used as future reference for modeling output circuits.
- Increase efficiency of new designs

Questions?