TRAVELING WAVE TUBE OUTPUT WINDOW MODEL
(IMPEDANCE MATCHING PROBLEM)

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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.
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

9 Turns-Loss away from Helix

19 Turns-Loss close to Helix

Attenuation Region
Tape Geometry

Straight Tape

Circular Tape matched with a real life circuit
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

\[ Zo = 138 \log(D/d) \]
\[ Er^{0.5} \]
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?