REMCOM®
Electromagnetic Simulation Solutions

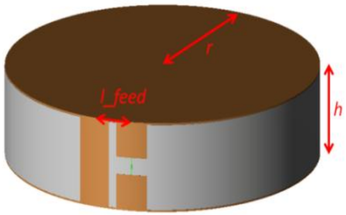
Path Gain and SAR Analysis of On-Body Antenna Optimized for Hearing Instrument Applications

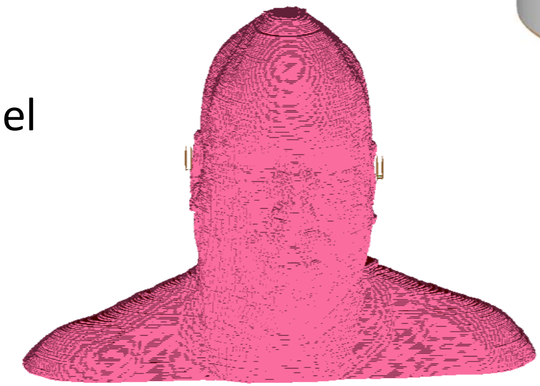
Evaluation in Presence of Different Human Head Models

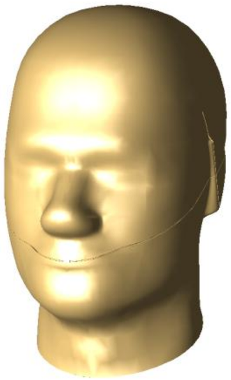
315 S. Allen St., Suite 416 | State College, PA 16801 USA | +1.814.861.1299 phone | +1.814.861.1308 fax | sales@remcom.com | www.remcom.com

Outline

- Introduction
- Motivation
- Simulation setup:
  - Antenna
  - SAM Phantom
  - Heterogeneous Head Model
- Simulation
- Results:
  - Tuning
  - Path Gain
  - SAR
- Conclusion
- Future Work

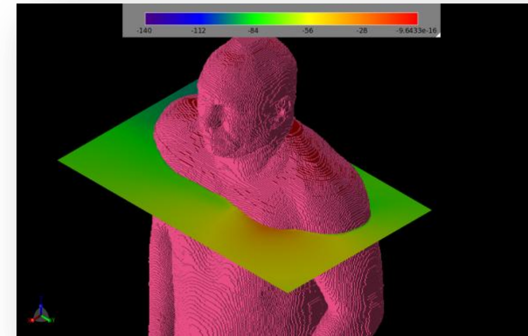


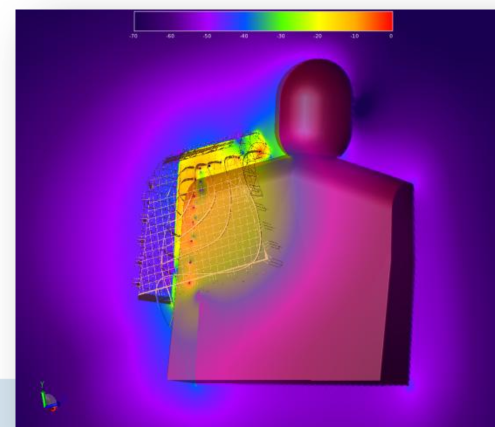




Introduction

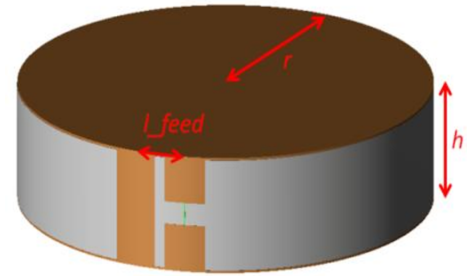
- Wearable, on-body, and implanted antennas are becoming increasingly popular.
- One particular application involves using hearing instrument devices to improve binaural hearing.
- Those devices filter incoming sound to not only enhance interpretation of sound, but also localization of the source.
- This type of processing requires communication between devices located in each ear.

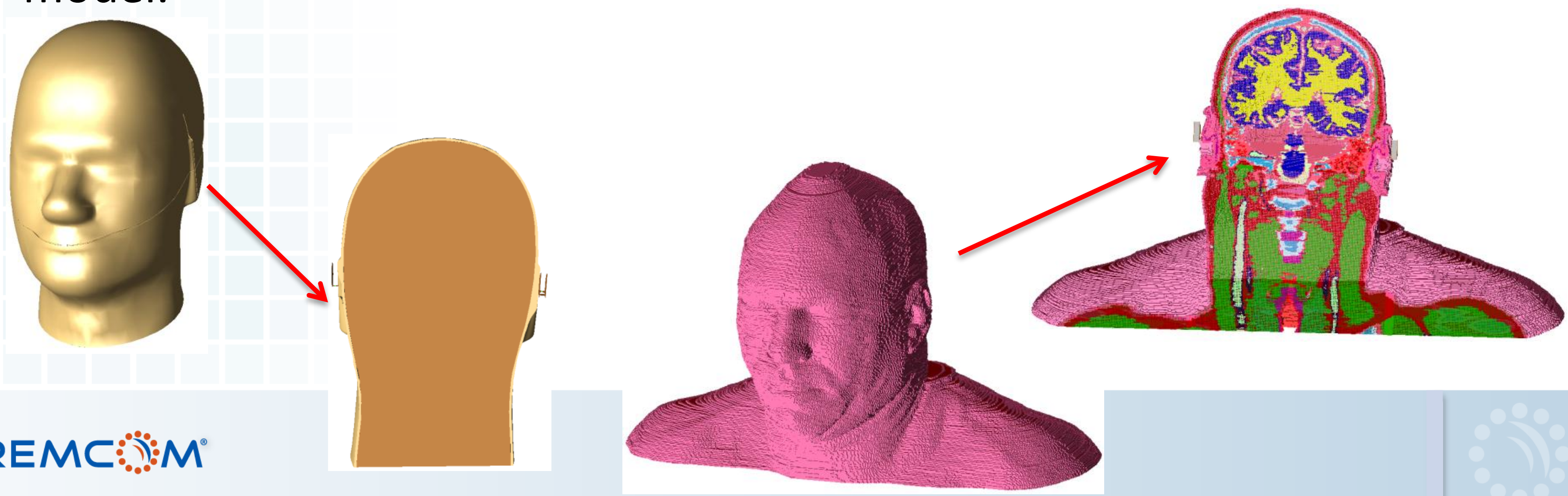




Introduction

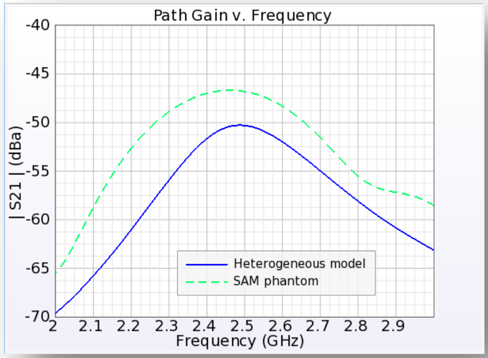
- We model one such device in the presence of a SAM Phantom and heterogeneous head model.
- Hearing instrument device is placed near each ear of each model.

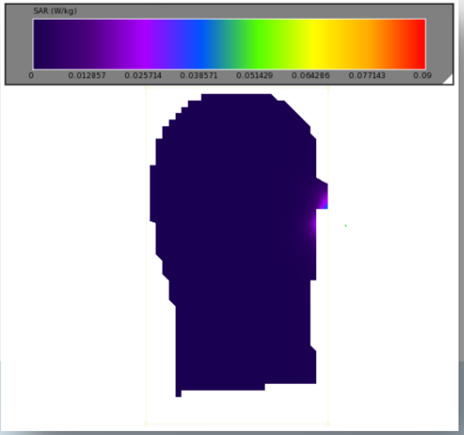




Motivation

- Test & measurement can be a good approach.
- Using a phantom is safe, but results may differ from “real life.”
- Human testing can be inconvenient, expensive, and potentially dangerous.
- Simulation using the [FDTD method] and a realistic head model permits rapid design and prototype in a benign environment.
- The simulation results show that there can be significant differences in ear-to-ear performance and SAR between the two types of head models, illustrating the importance of utilizing a realistic model as part of the design process.

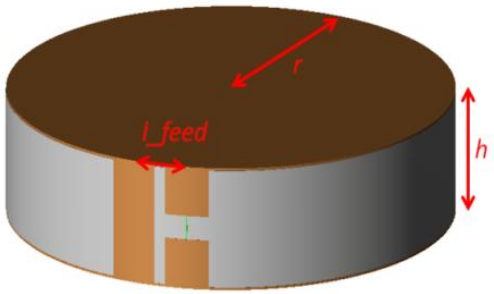


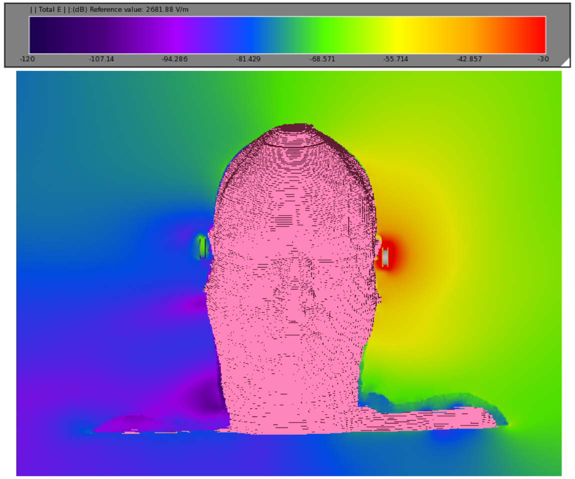


REMCOM®

Antenna

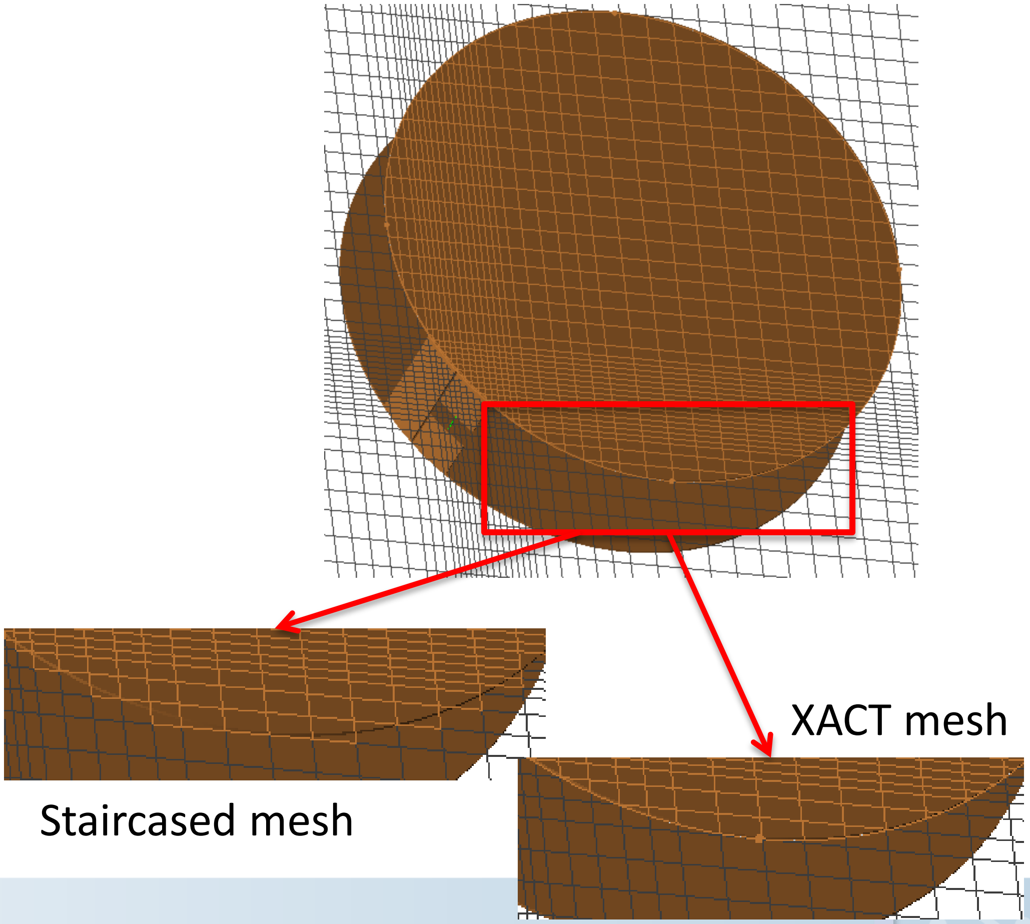
- An antenna design presented by Kvist and Jakobsen was simulated using XFdtd® EM Simulation Software.
- Structure utilizes dual discs connected by a short pin and balanced feed to create a PIFA-like radiator
- Can be optimized for maximum ear-to-ear path gain, taking advantage of a creeping wave with E-field components normal to the surface of the head
- Input impedance of the antenna is controlled by manipulating the *l_feed* distance





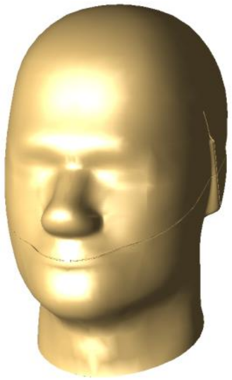
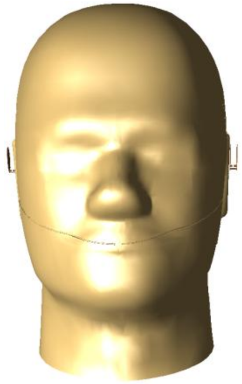
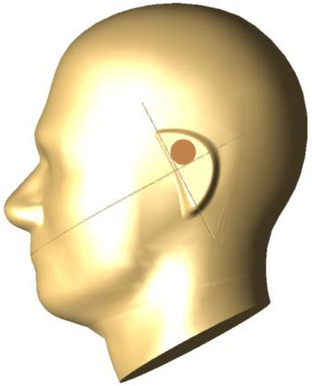
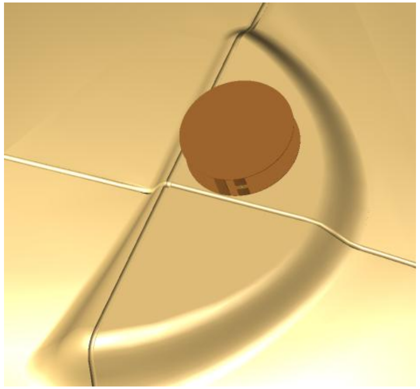
Antenna

- Want to find optimal *l_feed* distance
- A parameter sweep was performed to find the distance resulting with an input impedance of 50 ohms at 2.45 GHz.
- Simulated in XFdtd Release 7 using variable gridding and XACT Accurate Cell Technology®



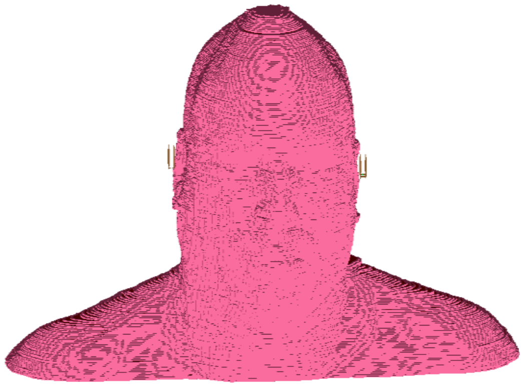
SAM Phantom

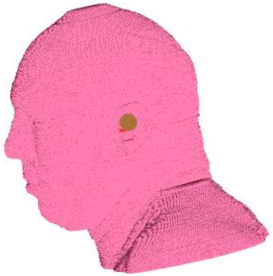
- SAM phantom can be used for test & measurement to determine SAR levels
- Used for simulation in XFdtd
- Device was placed near each ear, so main radiating lobe was tangential to surface
- SAM consists of lossless outer shell and inner liquid

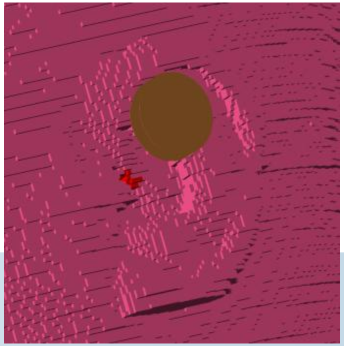





Heterogeneous Head Model

- Imported as a voxel object
- Represents internal structure of human male head
- Data collected as part of Visible Human Project
- Internal organs have appropriate electrical material properties
- Antenna placement is more complex due to the uneven ear surface





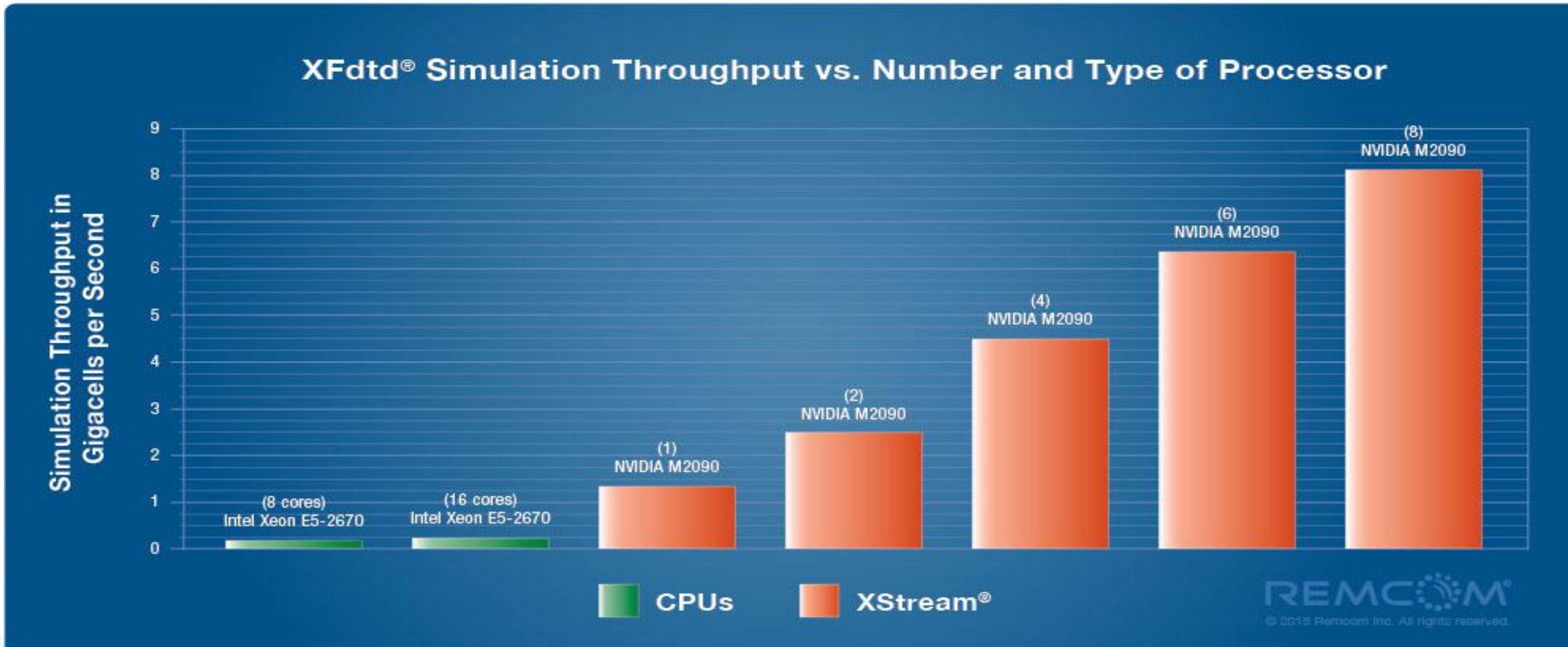


Simulation

- Heterogeneous head model simulation requires over 78.4 million FDTD cells
- Approximately 3 GB RAM
- Converges in about 34,300 time-steps
- Simulation time nearly 7 hours using 4-core Intel i7-2600k CPUs
- Using XStream® GPU Acceleration, simulation time 29 min., 27 sec.

XStream® GPU Acceleration

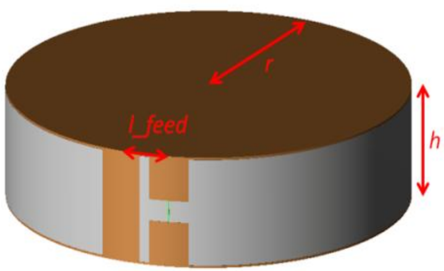
- Powered by NVIDIA's CUDA architecture
- Massively parallelized implementation
- Hundreds of times faster than a CPU

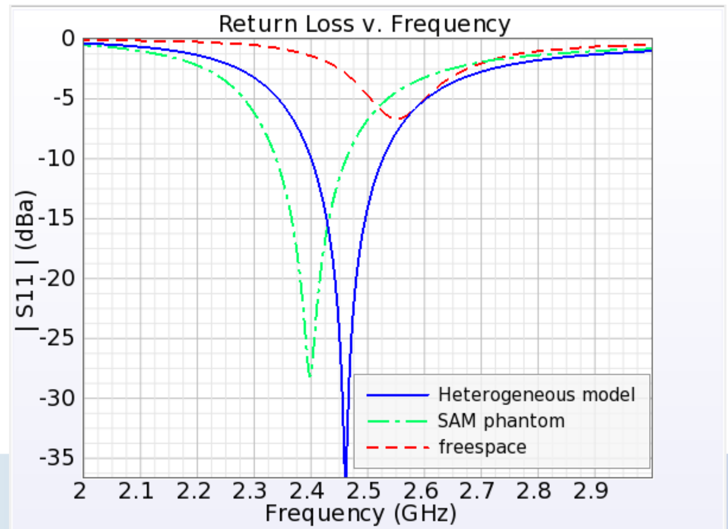


Results: Tuning

- Antenna tuning changes with each configuration.
- Optimal return loss was found for heterogeneous model configuration when *l_feed* was 3.5 mm.
- Performance differs for other configurations, so custom tuning is required.

Configuration	*l_feed* Value
Freespace	3.5 mm
Near SAM phantom	3.5 mm
Near heterogeneous head	3.5 mm



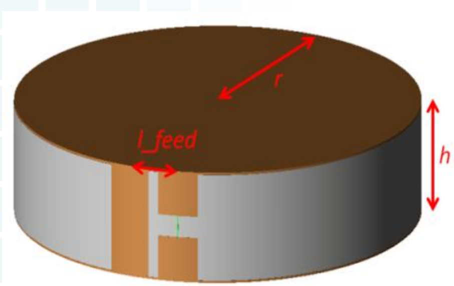


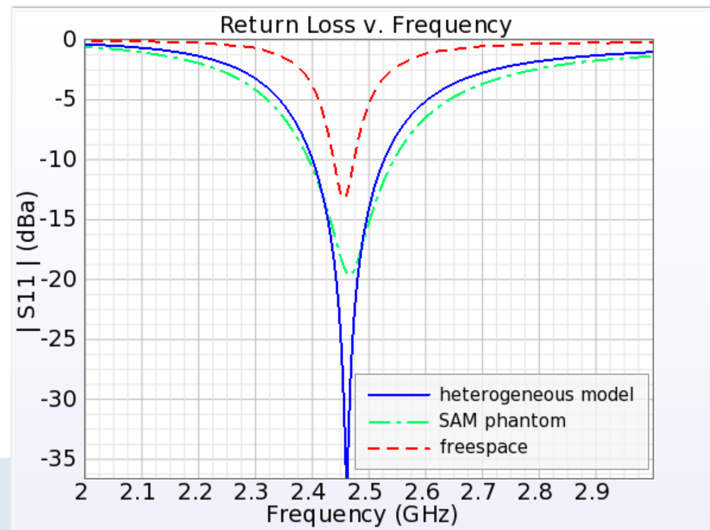
REMCOM

Results: Tuning

- Antenna was tuned individually for each configuration
- Parameter *l_feed* was created and sweep was performed to find 50 Ohm match

Configuration	*l_feed* Value
Freespace	2.625 mm
Near SAM phantom	4.5 mm
Near heterogeneous head	3.5 mm

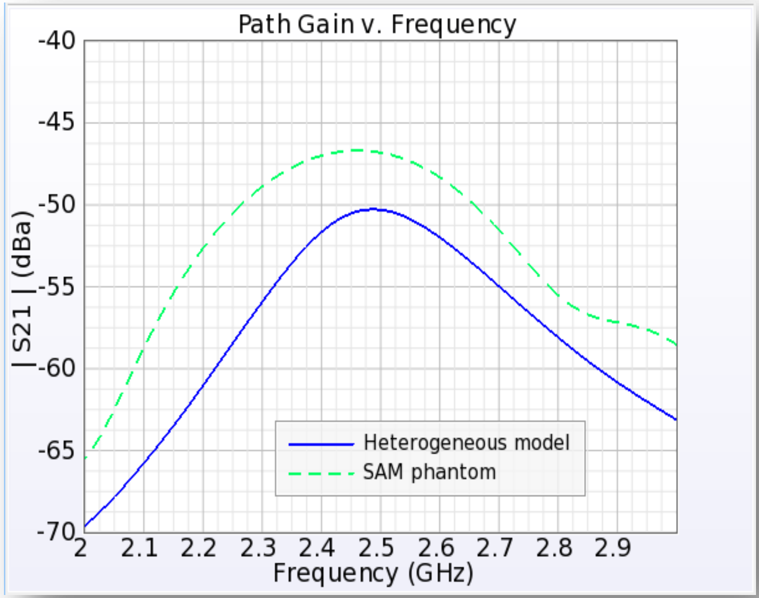




REMCOM

Results: Path Gain

- Both models show acceptable ear-to-ear path gain.
- Heterogeneous head attenuates more than SAM phantom, likely due to outer material in each model
  - SAM Phantom shell is lossless
  - Heterogeneous head has lossy skin material that dissipates -1.313 dBm



Results: SAR

- Device net input power scaled to 4 dBm
- Heterogeneous head results in higher SAR value, mainly because the antenna is closer to lossy tissue than in the SAM head case
- While within exposure limits in either case, the results illustrate the variation between models

	SAM Phantom	Heterogeneous Head
Maximum SAR (raw)	0.09745 W/kg	0.3753 W/kg
Max. SAR (10g ave.)	0.01995 W/kg	0.03432 W/kg
Max. SAR (1g ave.)	0.04682 W/kg	0.1214 W/kg

Conclusion

- The results obtained in this study show there can be a significant difference in the tuning, performance and exposure values between the homogeneous SAM phantom and a heterogeneous human head model.
- SAR values obtained (via simulation) using the SAM phantom can be lower than those calculated when a more realistic head model is used, likely due to the non-conducting shell surrounding the model.
- To ensure reduced exposure and maximize performance, it appears using a heterogeneous head model will yield more acceptable results and will improve the safety of the device when used by real human subjects.

Future Work

- Different antenna designs
- Positioning of the HI device
- Additional head models representing various sizes
- Total problem size enhancements permit simulation of whole body and even more realistic environment. Could include other transmitters, nearby objects, etc.

REMCOM® Electromagnetic Simulation Solutions

Contact us:

Toll Free: 1-888-773-6266 (US/Canada)

Tel: 1-814-861-1299

Email: sales@remcom.com

www.remcom.com

Free Trial: www.remcom.com/free-trial-request-form

Pricing: www.remcom.com/pricing

Information Request: www.remcom.com/information-request-form

Google+: https://plus.google.com/+Remcom/posts

Facebook: www.facebook.com/remcomsoftware

Twitter: twitter.com/remcomsoftware

LinkedIn: www.linkedin.com/company/remcom-inc