Smart Wearable Devices

OZEN ENGINEERING, INC.

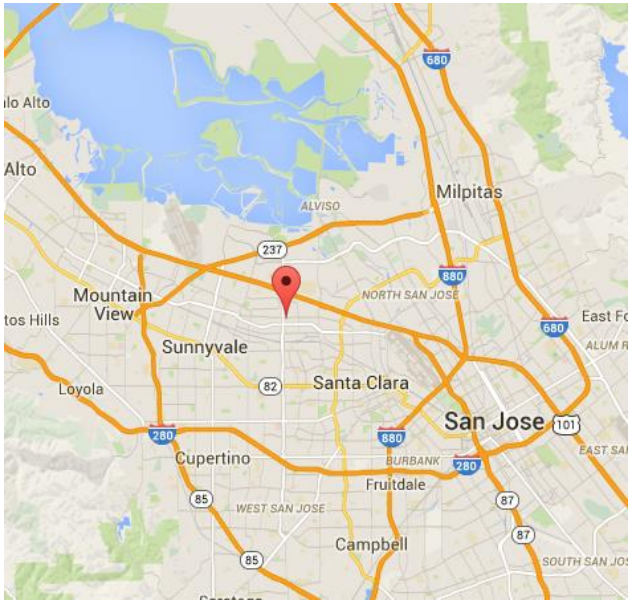
www.ozeninc.com

Outline

- Who we are
- Internet of Things (IoT)
- Smart Wearable Devices
  - Design Process
  - Electronics Challenges (RF and System Simulation)
  - Mechanical Challenges (Thermal and Structural Analysis)
- Summary

Ozen Engineering, Inc.

- Provides the local Ansys expertise in Silicon Valley
- Located in Sunnyvale
- No ticket system for support!
  - Call us (a live person will pick up)
  - Walk-in (bring your problem and work on it with us)
  - Email us (no automated responses)



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With over 30 years of experience in Finite Elements Simulations and Engineering Consulting, we collaborate with customers to provide the best in class expertise and solutions to their problems, enabling them to succeed.

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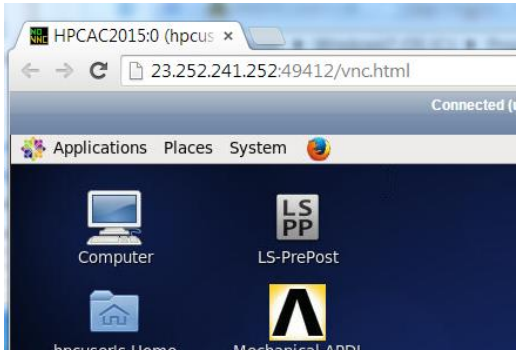
OzenCloud



- Instant compute capacity
  - Computing power without administrative overhead
- Familiar desktop GUI and workflow
  - Remote desktop for full pre/post processing
- Easy file transfer with Dropbox
  - Box.net/SSH/other methods also available

Dropbox

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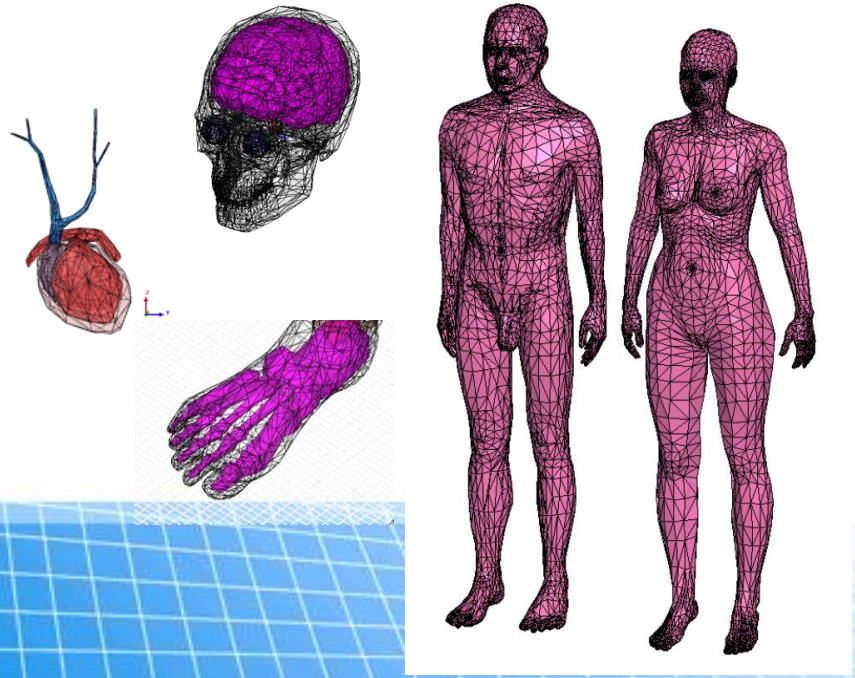
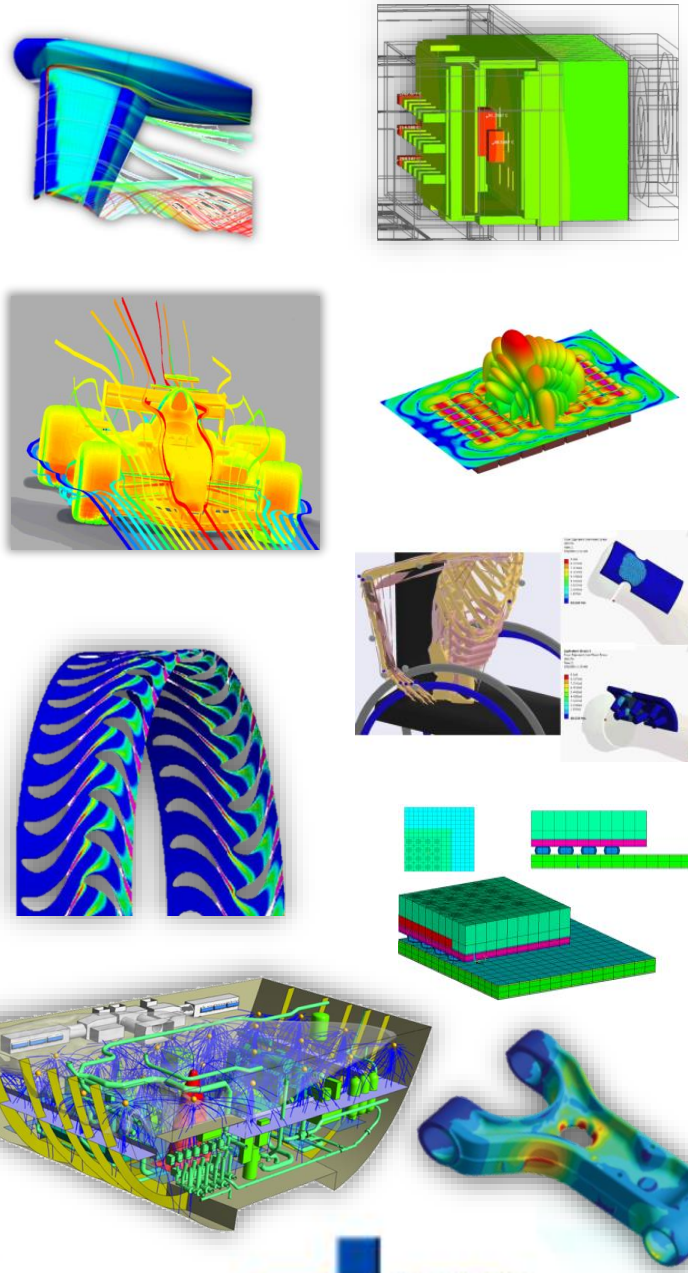
ANSYS

- Market leading FEA
- Market leading CFD
- Market leading Electromagnetics
- CAD independent
- Depth and breadth
- HPC R&D
- Human Body Model





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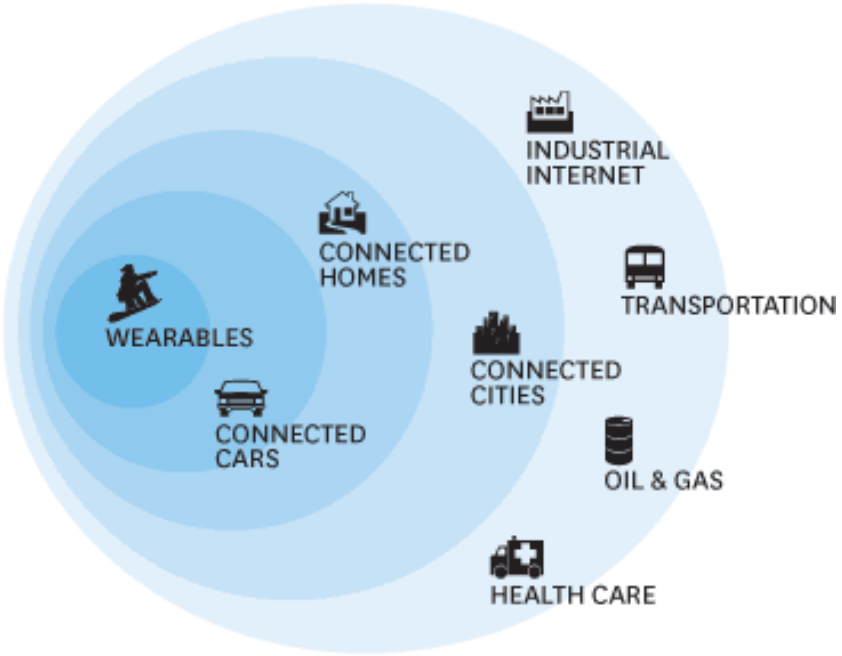
Internet of Things (IoT)

"Smart" interconnected devices

→ 50 Billion connected devices by 2020



SOURCE GOLDMAN SACHS GLOBAL INVESTMENT RESEARCH HBR.ORG

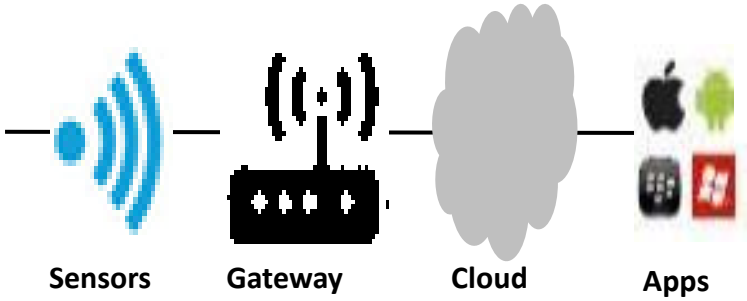
→ Automatic sensing (M2M)

→ Human interaction (H2M)

→ Connectivity

→ Cloud

→ Analytics



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Engineering Challenges for IoT

Things
Sensing & Processing

Network
Network, Gateway, Supervisory Logic

Data/Cloud
Storage & Analytics

- Antennas
- Power
- Prescriptive Analytics
- Embedded Software
- Structural & Thermal

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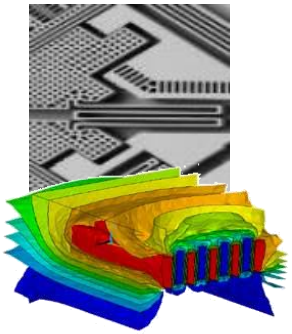
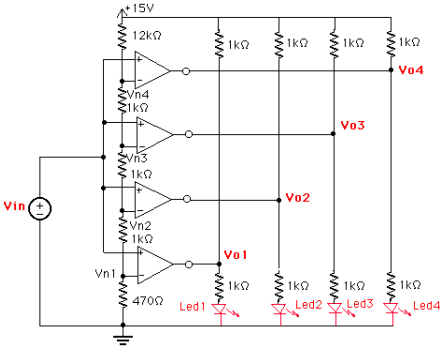
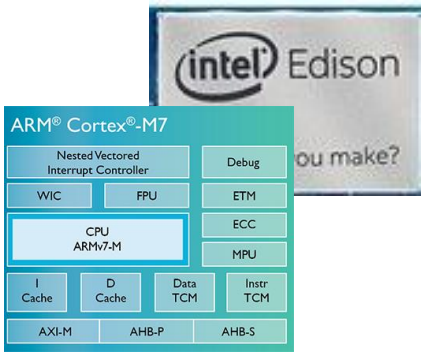
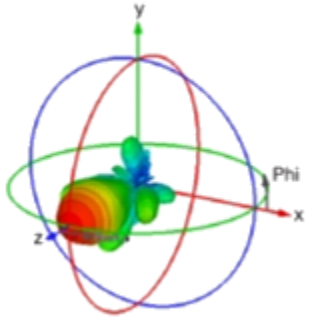
Machine to Machine Interaction

Capture data → Process data → Communicate

Sensor	Analog	Processor	Antenna
			
Robust low-cost MEMS	**Low cost Integrated ADC**	**Low power Processor**	**EMC compliant**

ADC: Analog to Digital Converter

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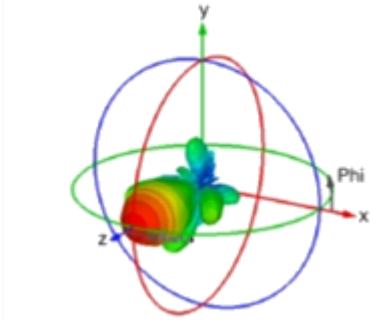
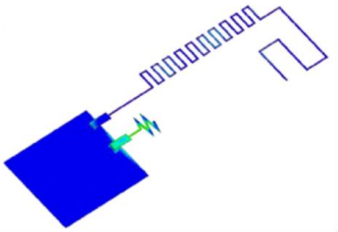
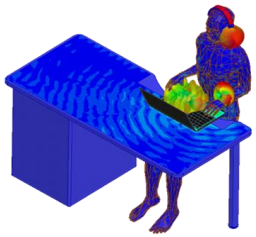
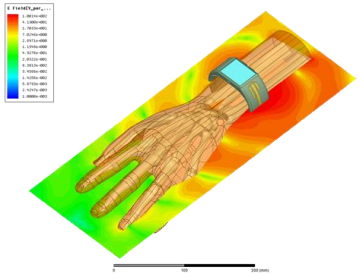
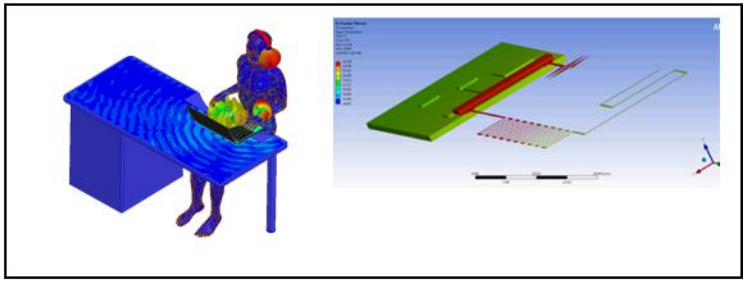
Contour Plots

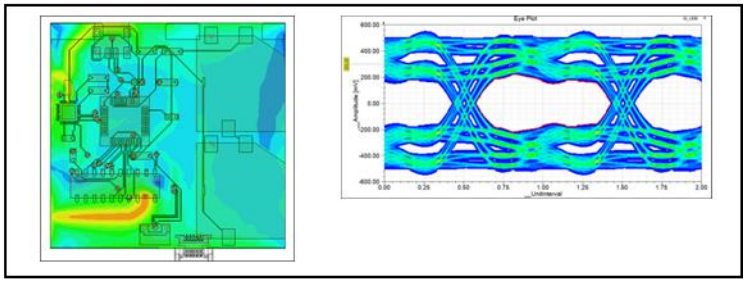


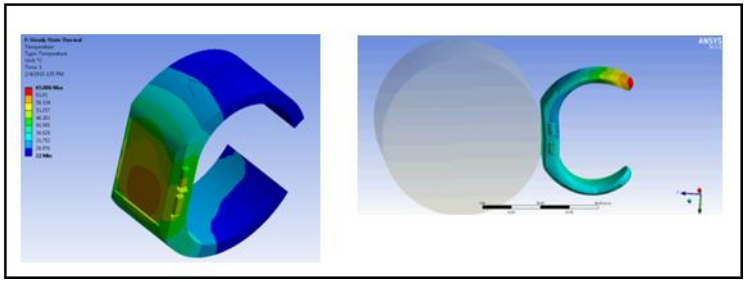












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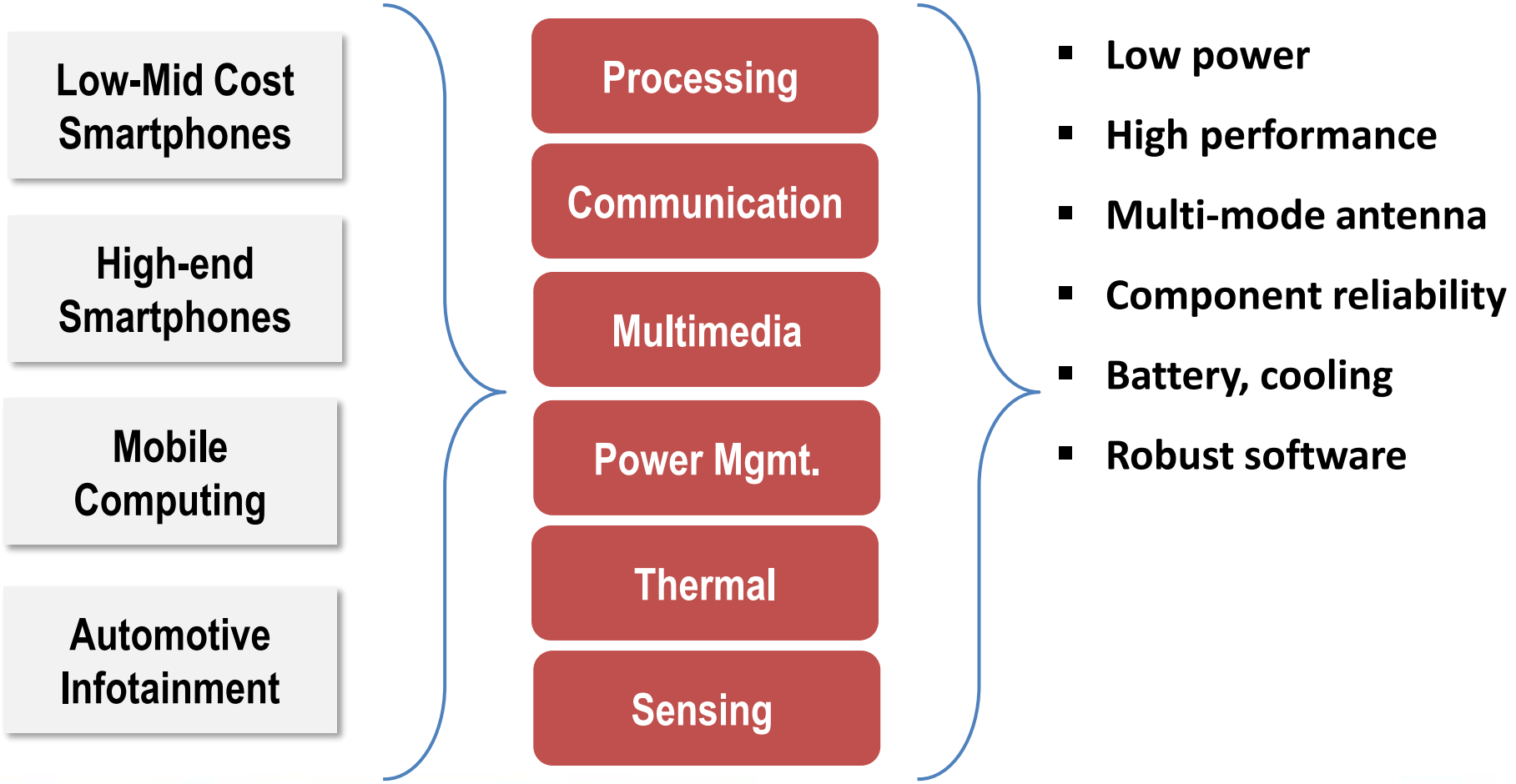
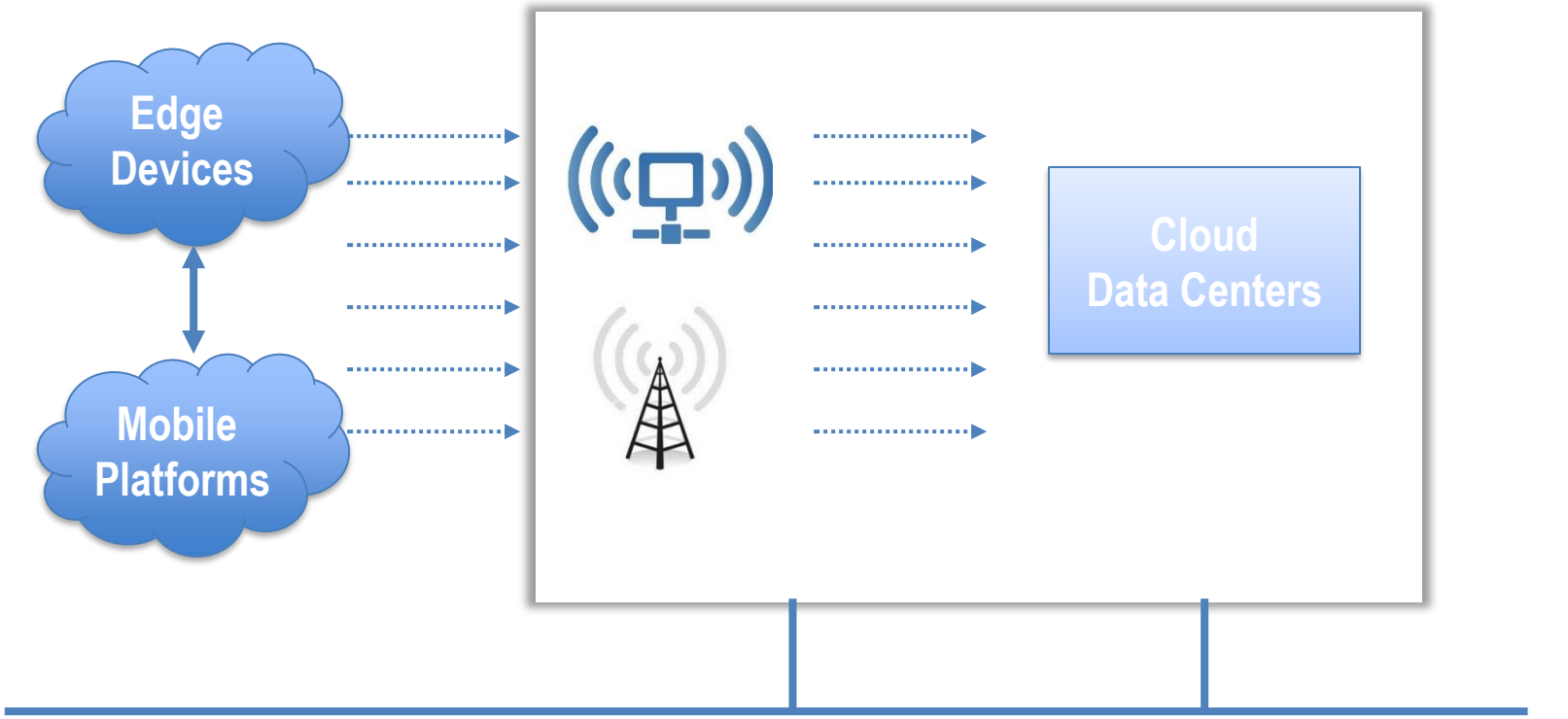
Human to Machine Interaction



Connectivity and Cloud Infrastructure



Robust Antenna

Performance Per Watt

High Speed Interfaces

System Cooling

An edge device is a device which provides an entry point into enterprise or service provider core networks. Examples include routers, routing switches,...

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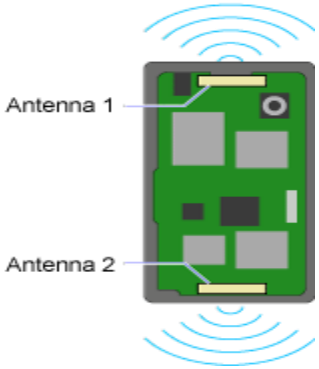
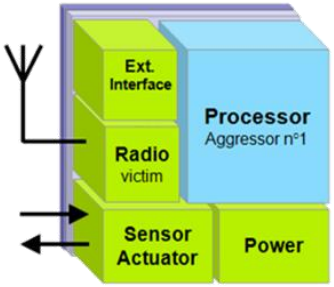
Common Design Challenges and Solutions



High-Fidelity Communication

The electronic reproduction of sound with minimal distortion.

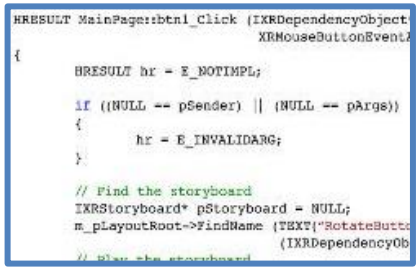


Mixed-signal Processing

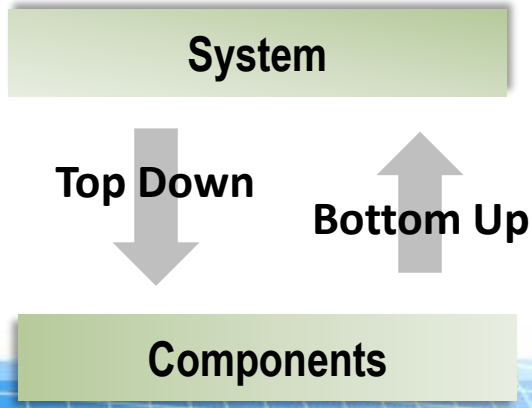
Digital processing & analog circuitry

https://www.tindie.com

Cost Optimized Electronics



Fault-free Embedded Code



- **Simulation driven virtual prototyping**
- **Multi-variable optimization**
- **Cross-functional collaboration**

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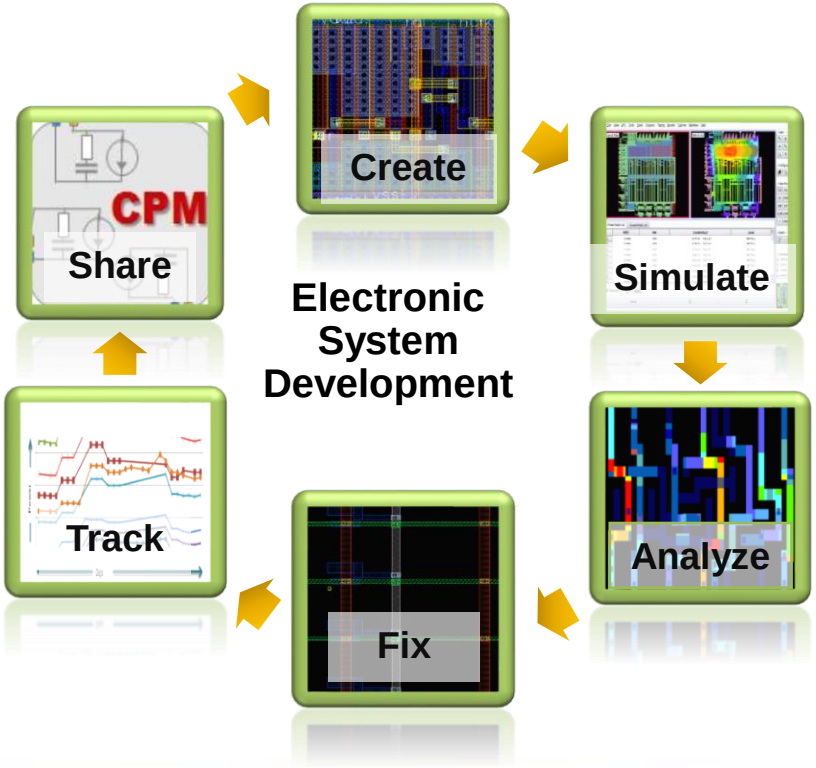
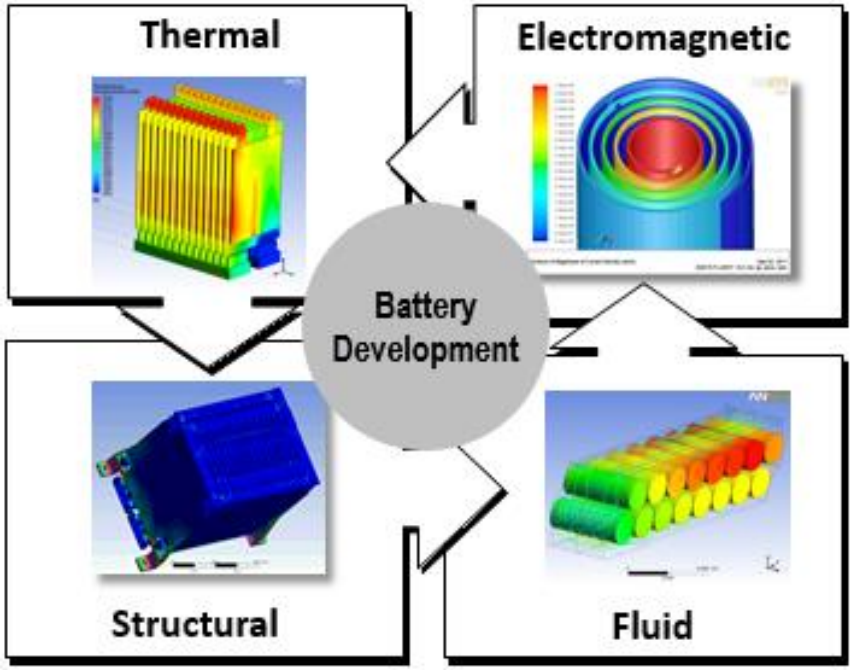
Component Validation and Sign-off

Converge on individual physics





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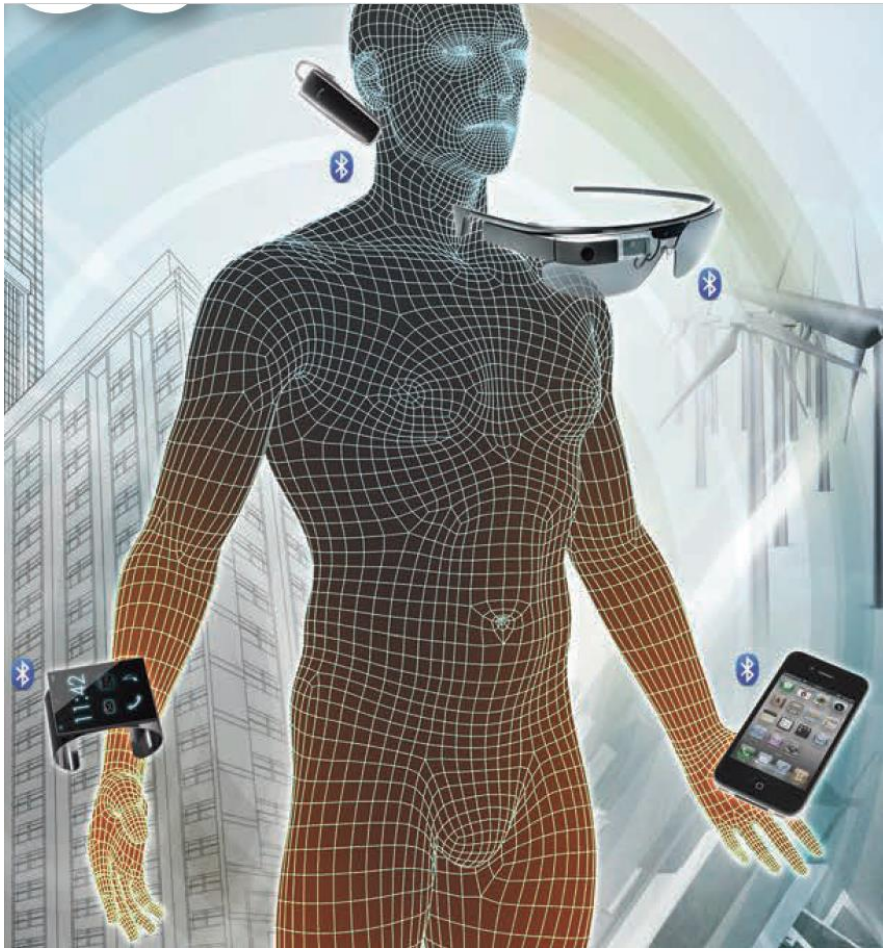
Smart Wearables Technology

Wearable electronics have quickly become an integral part of our lives. Smartphones, smart watches, Health/Medical devices, and fitness bands are enabling us to stay more connected and productive.



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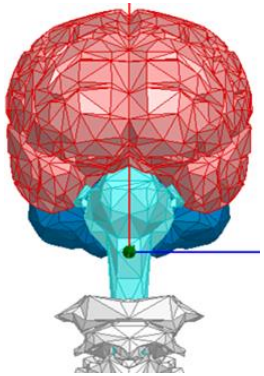
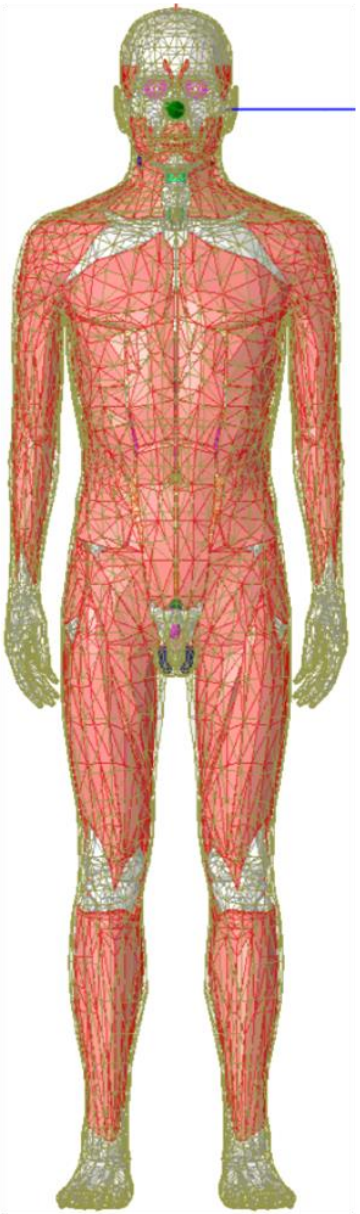
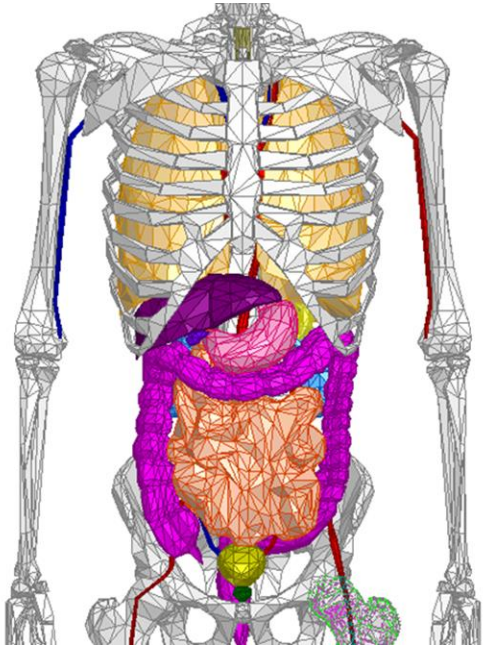
Human Body Model

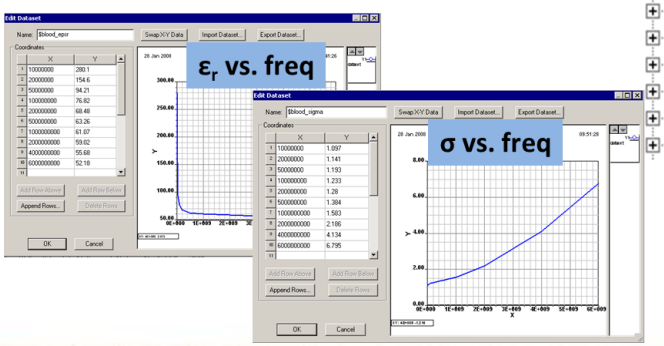
- Up to 304 objects for most detailed model
- Can turn parts of on/off depending on their significance.
- Individual body part visualization
- Frequency dependent materials are included for all body parts (from 10 Hz to 10 GHz).







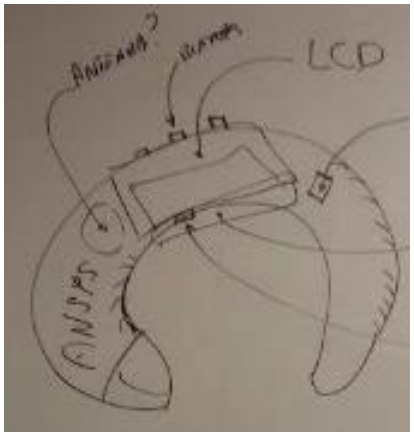
Frequency dependent materials built-in

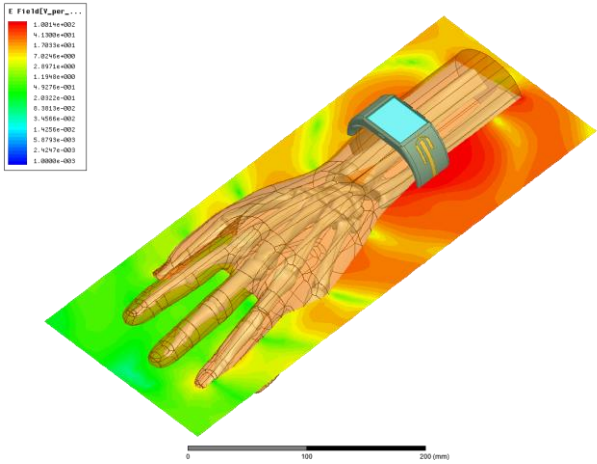


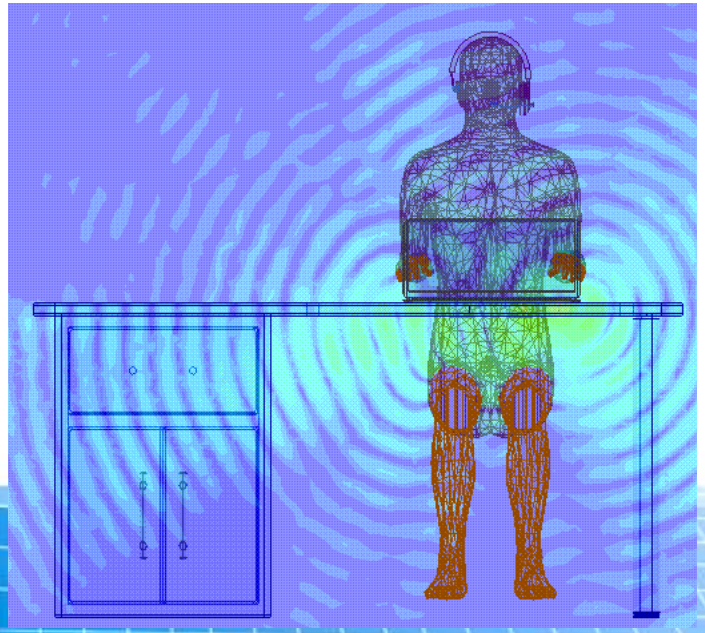
- human_average
- human_bone_cancellous
- human_bone_cortical
- human_brain_avg
- human_cartilage
- human_cerebellum
- human_eyes
- human_muscle
- human_spinal_chord
- human_tongue

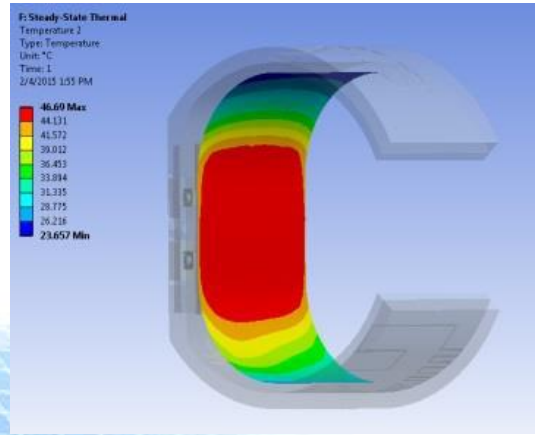
Male Body Model with all organs and tissues

Smart Wearable Case Study: Smart Watch









2400 MHz

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Smart Wearable Design Process

Electronics System
- Antenna Performance
- PCB Performance
- Charger Performance

Tools needed:
- HFSS
- SIwave
- Maxwell
- SpaceClaim

System Design Goals
- Performance
- Durability
- User Experience
- Cost

Control Design
- Wireless Control
- Data Processing

Final Product

System simulation

Tools needed:
- Scade Systems

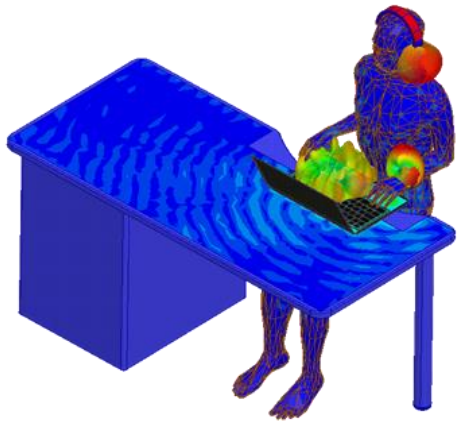
Mechanical System
- Mechanical Durability
- User Experience
- Manufacturability

Tools needed:
- ANSYS Mechanical
- SpaceClaim

System Design Goal

The Smart Watch will:

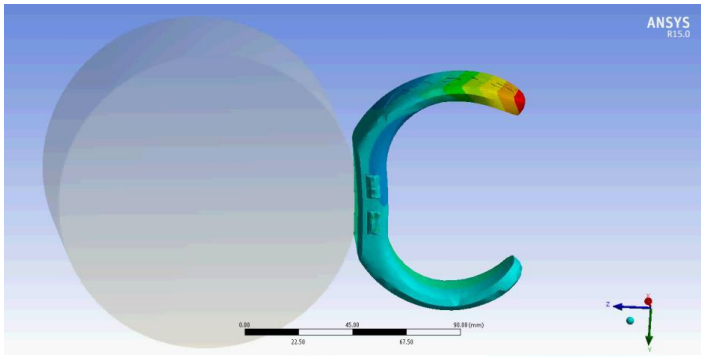
- Perform Health Tracking (Blood pressure, Pulse rate, etc…)
- Stream music via Bluetooth speakers,
- Display Smart Watch functions on LCD



– **Key Electronics Systems**
  – Omni-directional Antennas
  – 3 layers board within 4X4cm
  – Wireless power charging

– **Key Mechanical Challenges**
  – Impact resistant
  – Manufacturability
  – Comfortable to wear

– **Control System**
  – Control two wireless systems simultaneously
  – Generate a robust code to ensure accurate measurement and display of health data.



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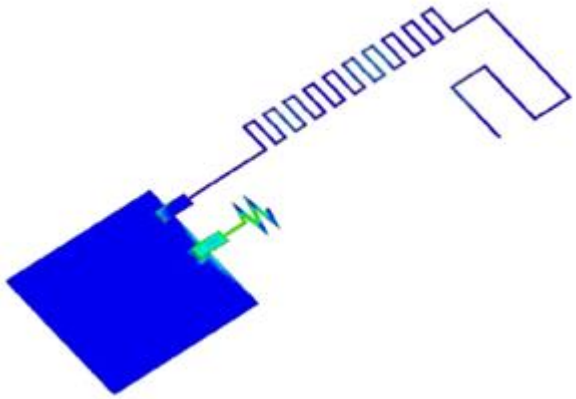
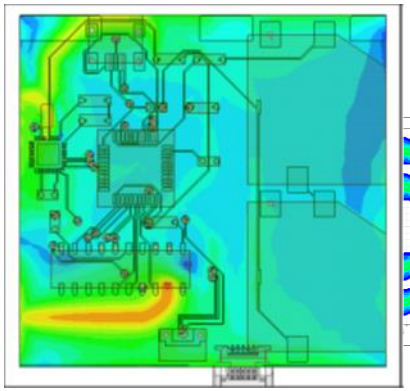
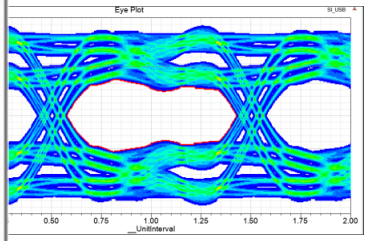
Electronics System

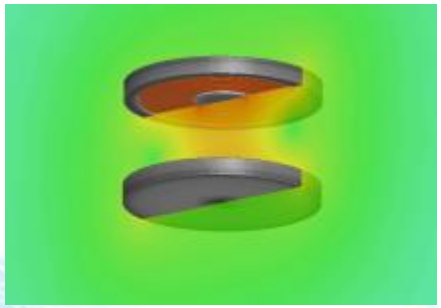
- **Antenna Design**
  - Start with a basic design
  - Wrap antenna around the wristband
  - Tune Antenna to vastly improve performance
- **Power and Signal Integrity**
  - Start with an initial layout
  - Verify critical paths in PCB layout
  - RF & Critical Digital interconnects
  - Improve layout to handle high speed data
- **Wireless Power charger**
  - Design and Optimization of the Wireless power charger







Eye Diagram



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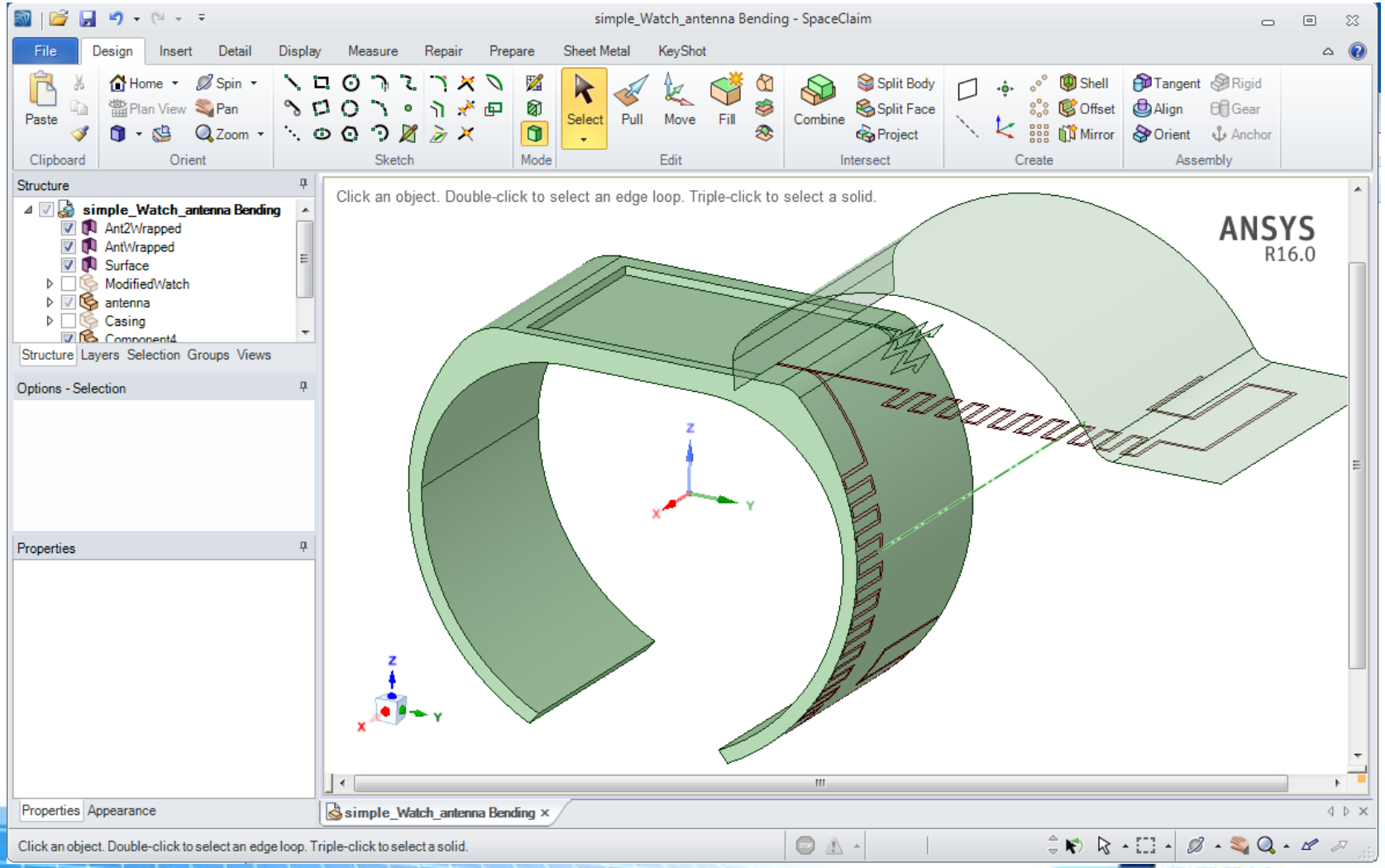
Geometry

SpaceClaim is used to create and prepare the simulation geometry



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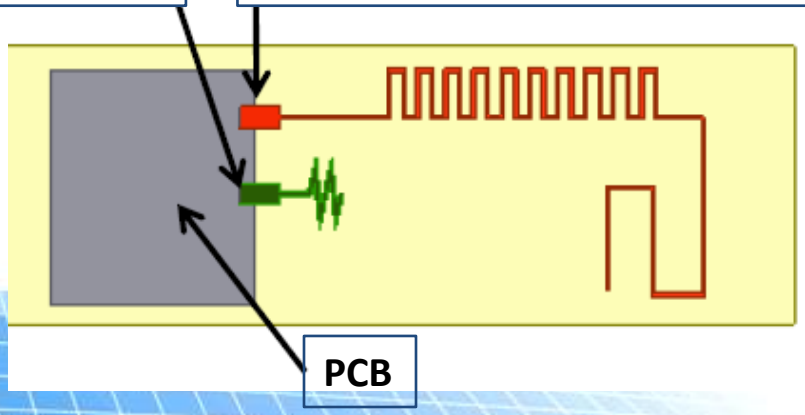
Antenna Design for a Smart Wearable Devices

- Antenna Design Using HFSS
- Multiple antennas on a device create interference
- Wrapping of antennas degrades performance
- Parametric simulation can address these challenges

1) Bluetooth Antenna:
- 2.4-2.485 GHz
- Return Loss= less than -10 dB
- Flexible substrate

2) Bio-sensor Antenna:
- 400-450 MHz
- Return Loss= less than -10 dB
- Flexible substrate



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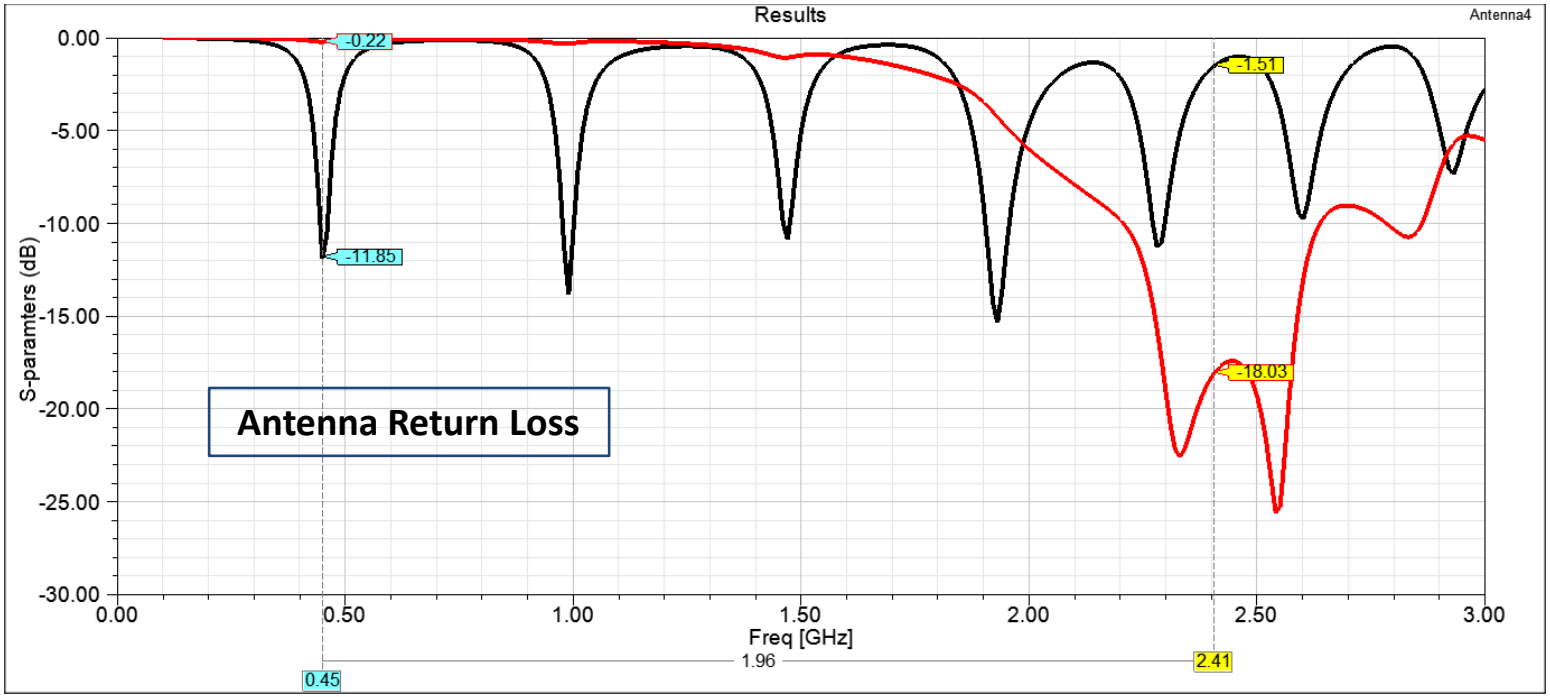
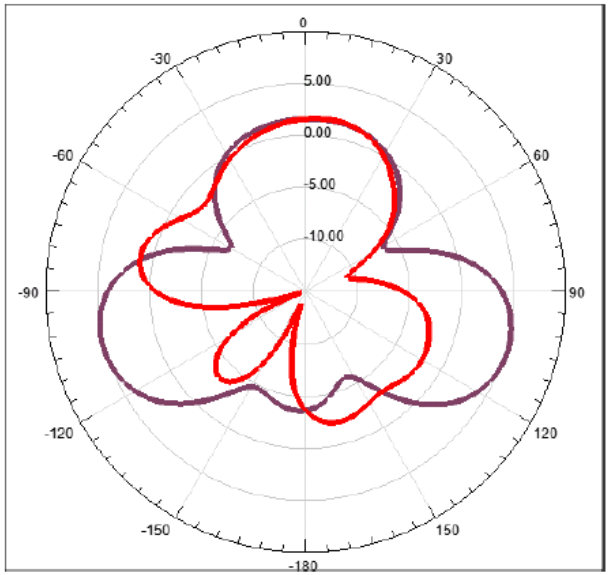
Antenna Design Results

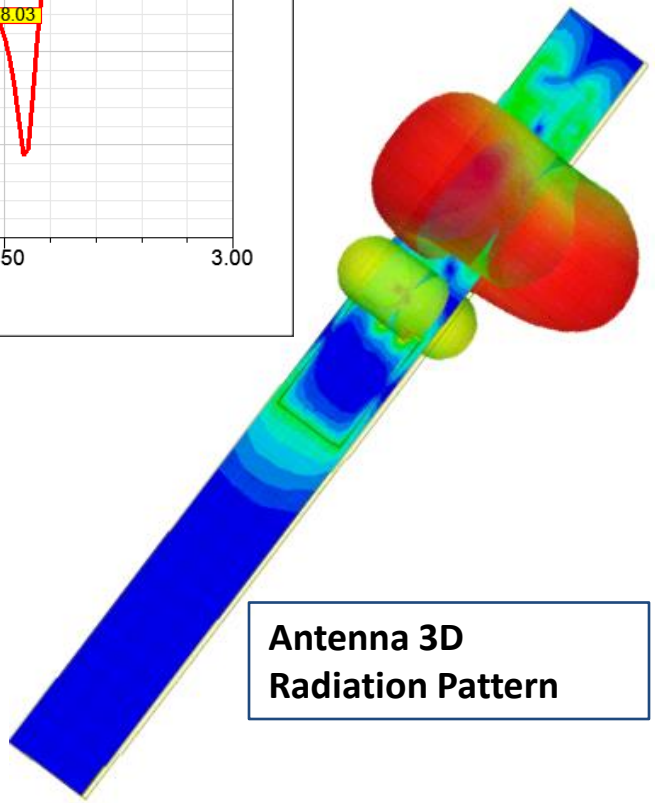
S11 is a measure of how much power is reflected back at the antenna port due to mismatch from the transmission line



Antenna Return Loss

Antenna 2D Radiation Pattern





Antenna 3D Radiation Pattern

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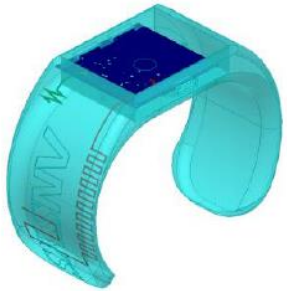
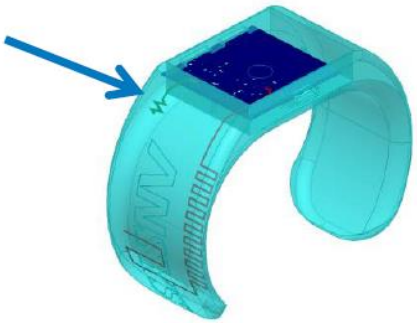
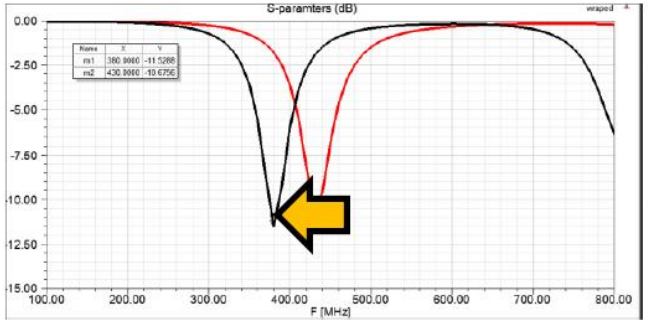
Antenna Wrapping – Optimized

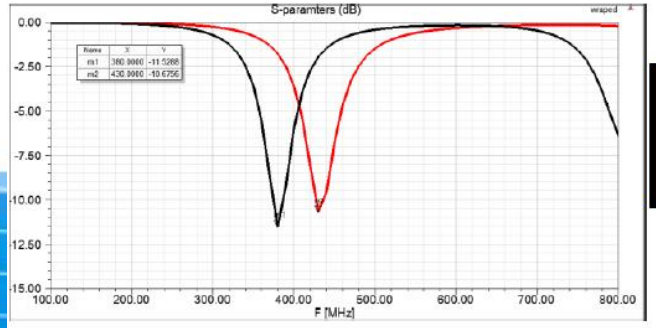




Bio-sensor

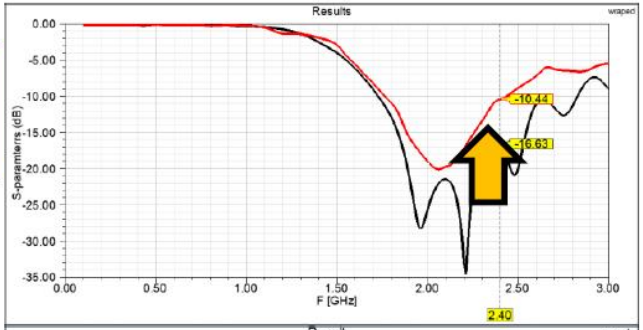


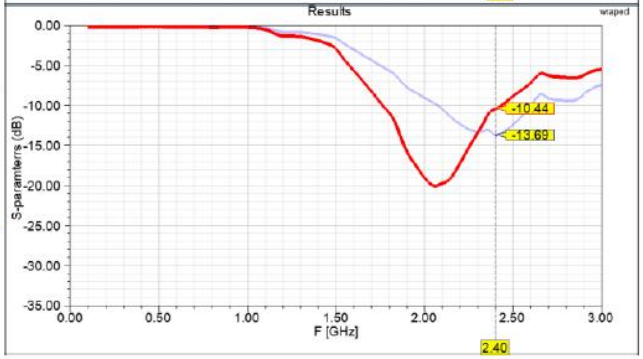
Both antennas performance is effected by wrapping



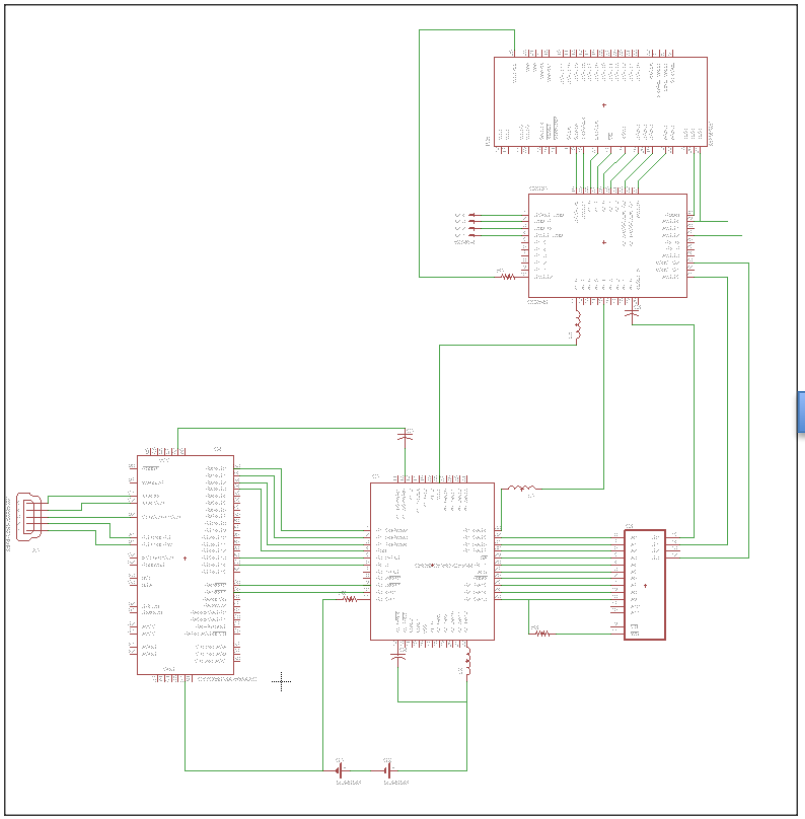
Problem fixed using parametric optimization!

Bluetooth

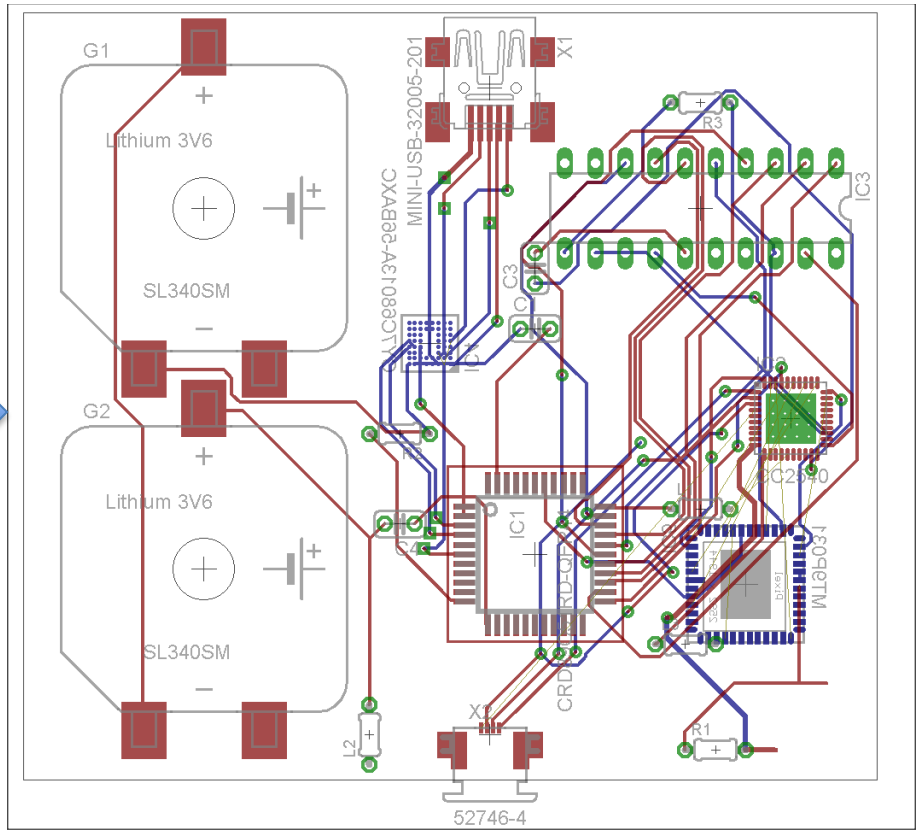




PCB Power and Signal Integrity



Schematic



Layout

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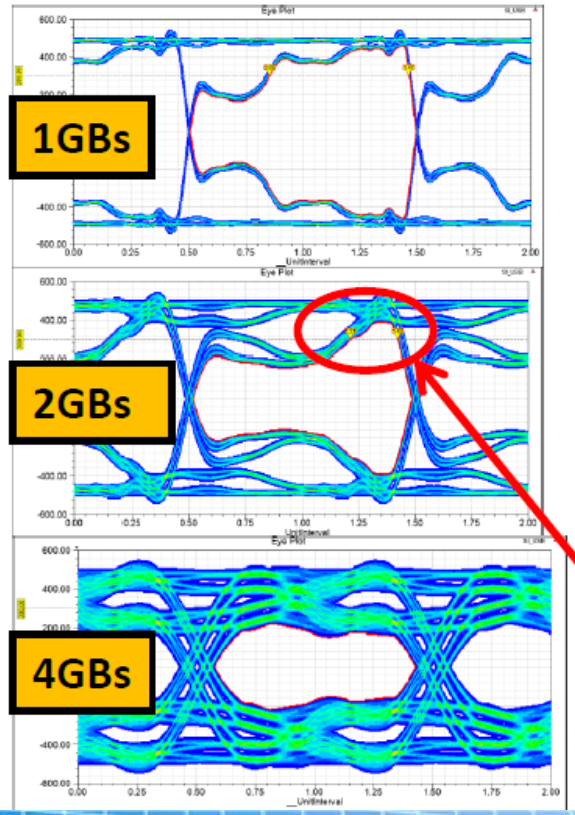
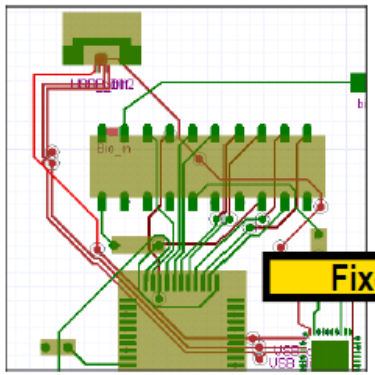
PCB Power and Signal Integrity

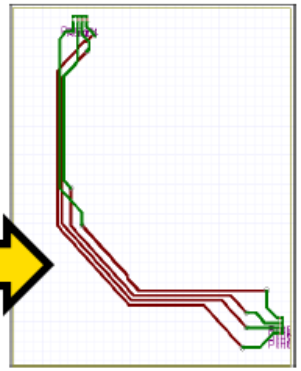
- **SI, PI, and EMC/EMI using ANSYS HFSS & ANSYS SIwave**



Original Design

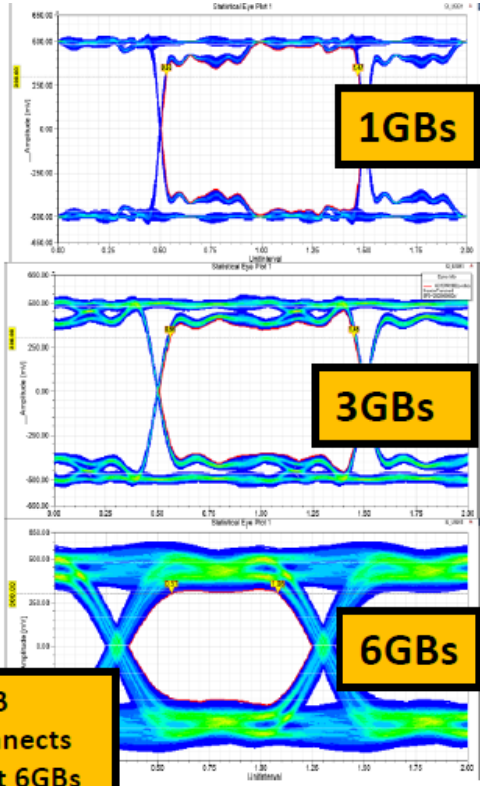


New Design



Fixed!

USB Interconnects fails the specs at 2GBs



USB Interconnects passed at 6GBs

Critical Interconnects > USB

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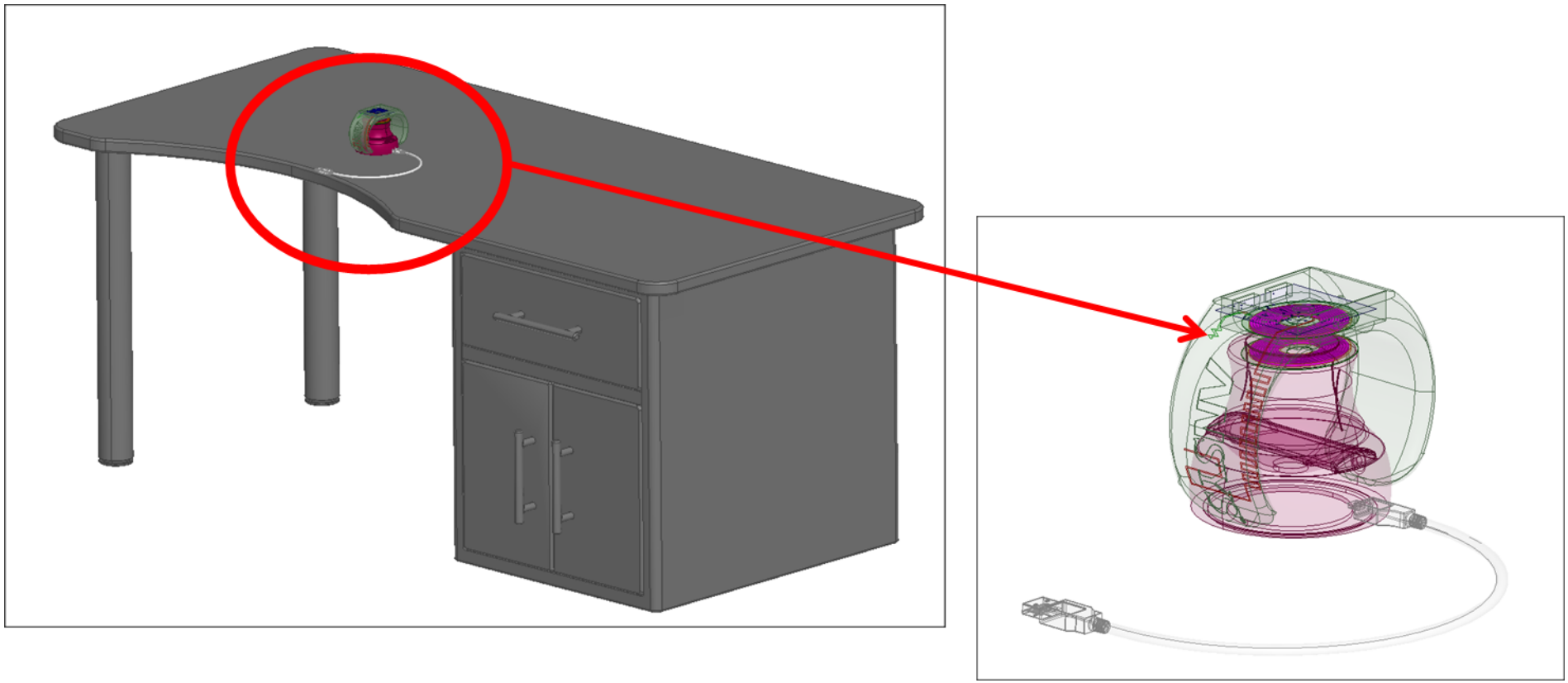
Wireless Charger > Transformer Design



Optimize the performance of Wireless Power Transformer

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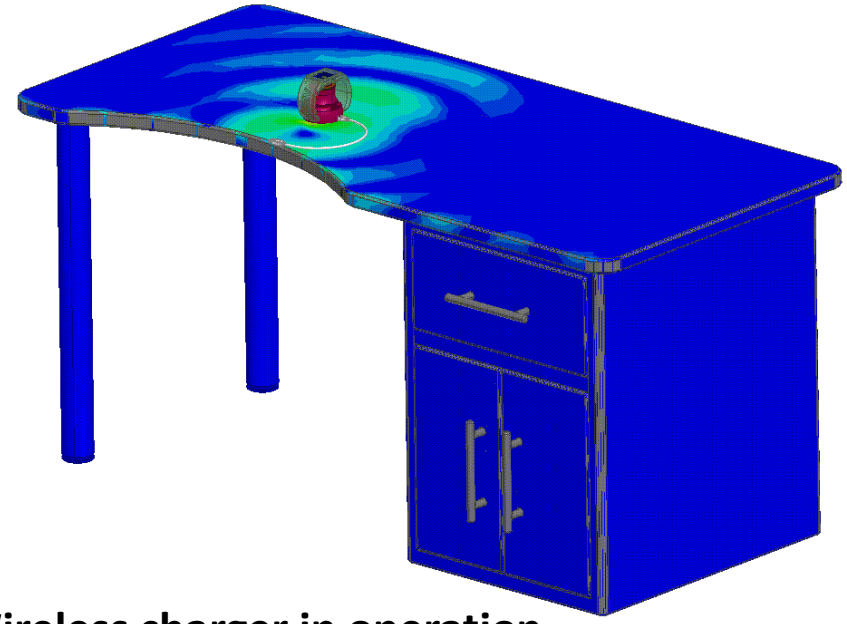
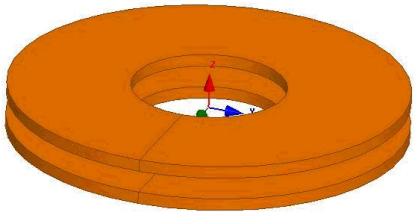
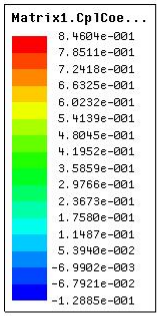
Wireless Charger > Optimized Transformer in Maxwell

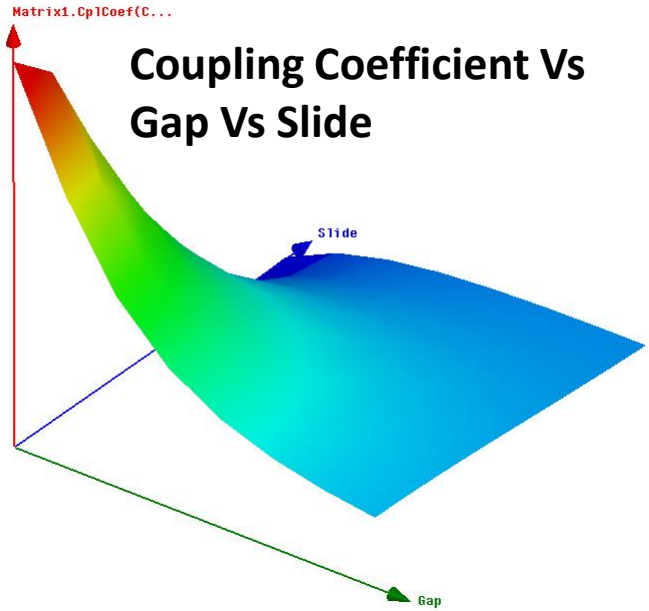


Wireless charger in operation



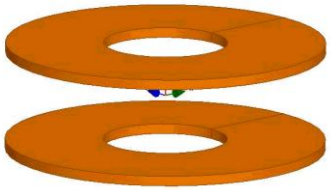
Charger Gap





Coupling Coefficient Vs Gap Vs Slide

Charger Sliding



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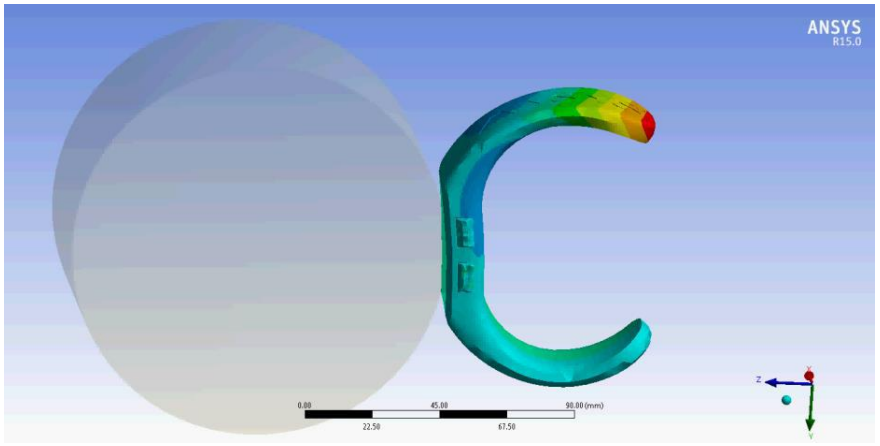
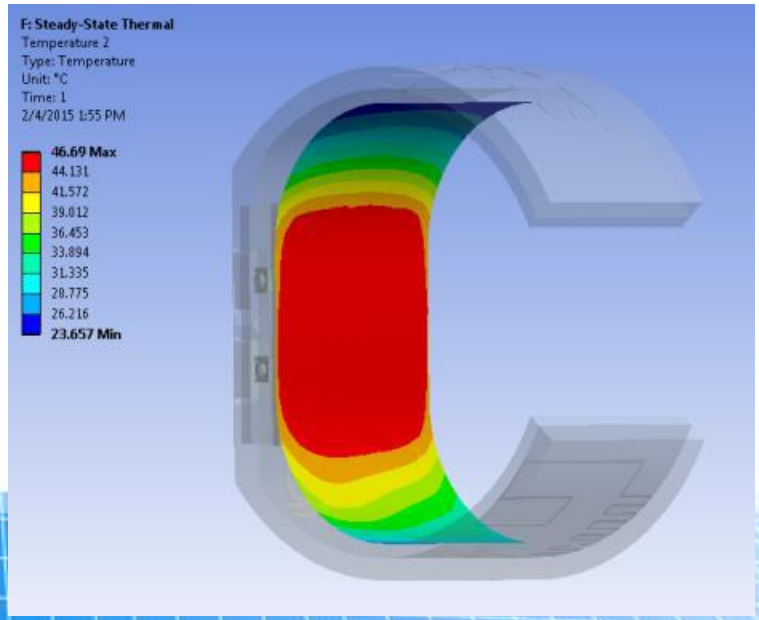
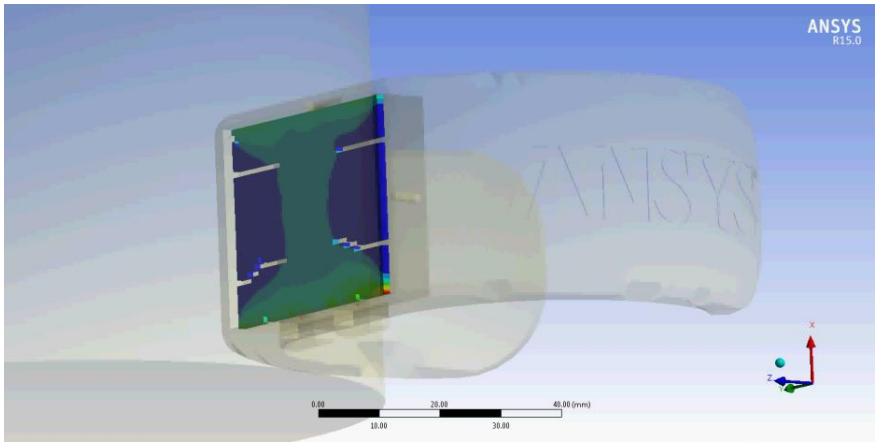
Mechanical Challenges

- Manufacturing Process
- Thermal
- Impact/drop
- Reliability
- User experience







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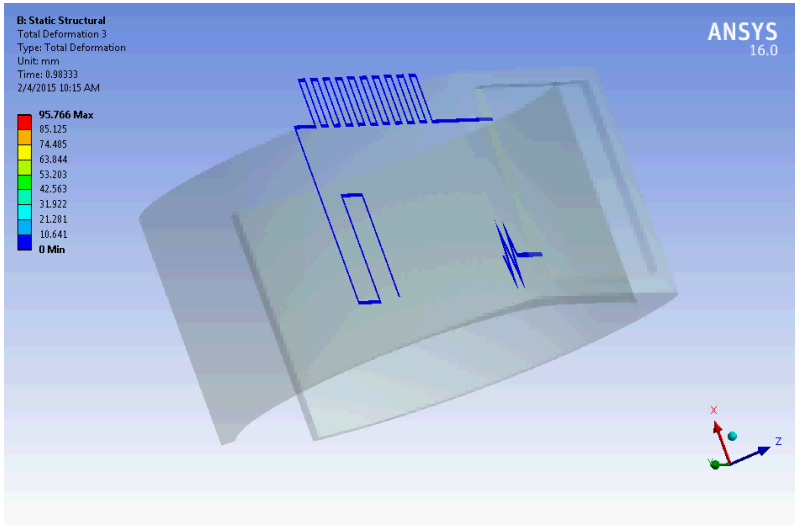
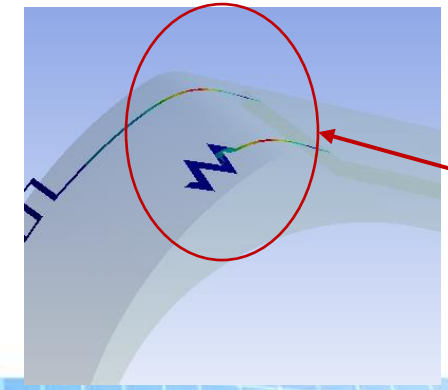
Manufacturing challenges

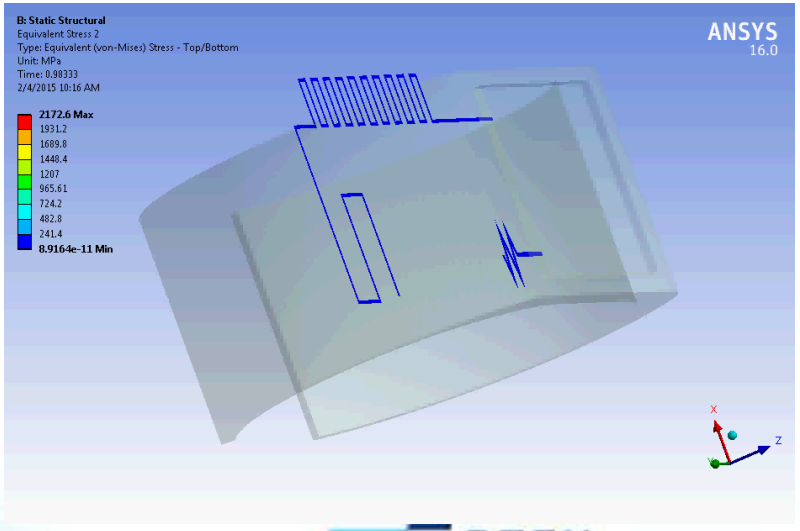
Forming of the Antenna

- In the ANSYS Wristband, the antenna need to be wrapped around curved wristband.
- This introduces stress in the antenna and may cause failure.
- In the initial design, the stress around the bend was too high. This was adjusted to improve reliability during manufacturing.





Adjusting the radius of curvature helps to reduce the stress during the forming of the antenna



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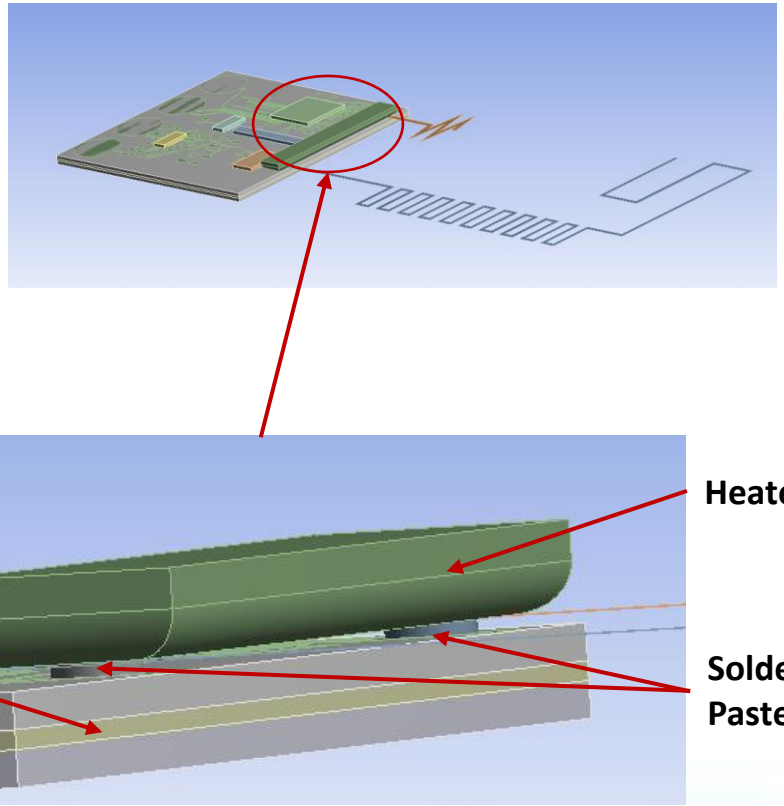
Electronics Assembly Process

- The use of lead free solder and flexible PCB introduces many challenges during electronics assembly.
- Lead free solder requires high soldering temperature while flexible PCB can not tolerate high temperatures. This means soldering process needs to be designed carefully in order to insure good connections while minimizing damage to the PCB.
- The goal is to ensure that solder paste is heated to the right temperature for the manufacture recommended duration while other components do not exceed the manufacture recommended temperatures.

Soldering Assembly



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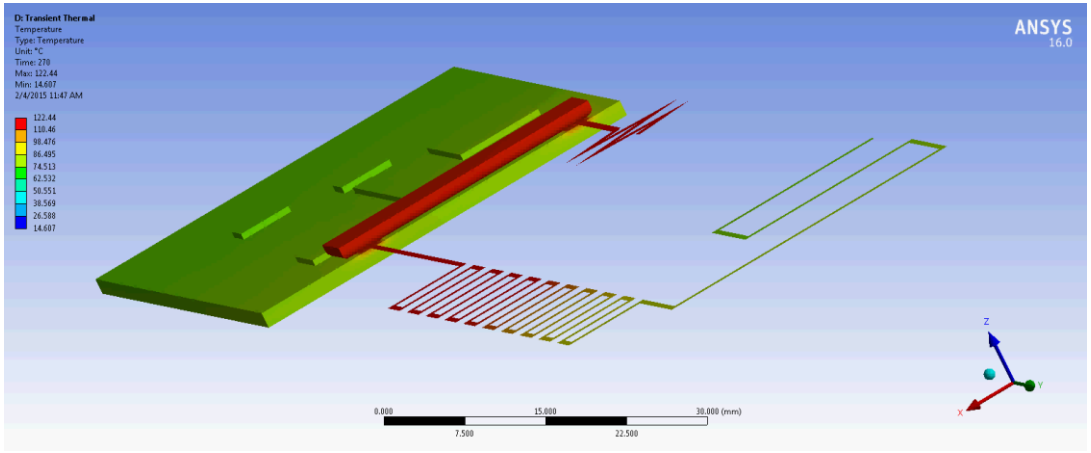
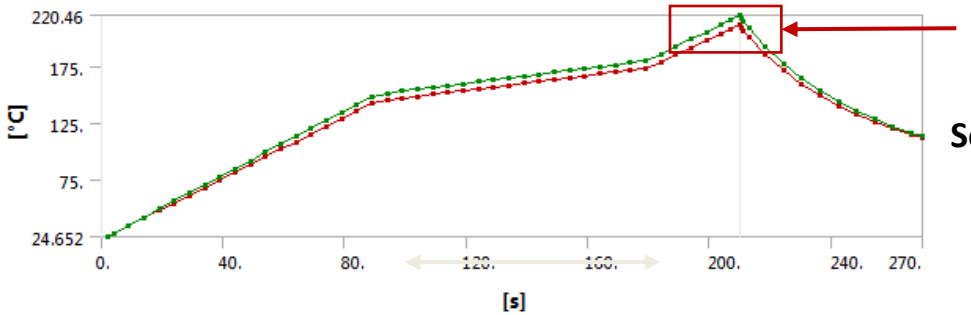
Electronics Assembly Process

- Simulation of the soldering process allows designers to predict the temperature of each component throughout the solder process.
- By adjusting the duration of and heat load for each soldering step, a high quality assembly process can be maintained.

Solder process temperature

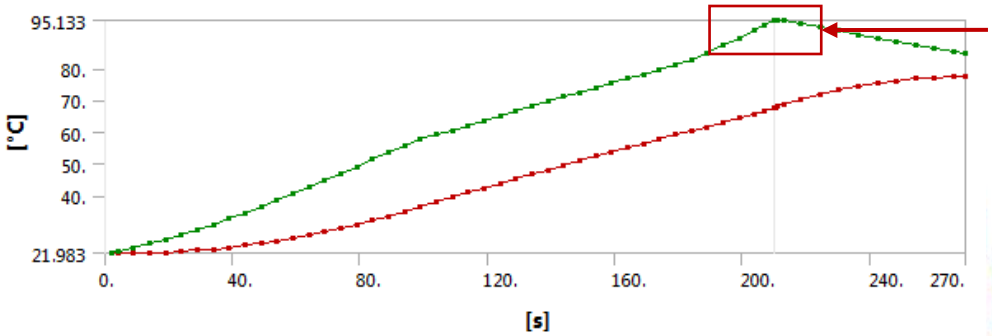




Solder melting

Solder Temperature

Adjust heating profile to insure PCB is protected



PCB OK

PCB Temperature

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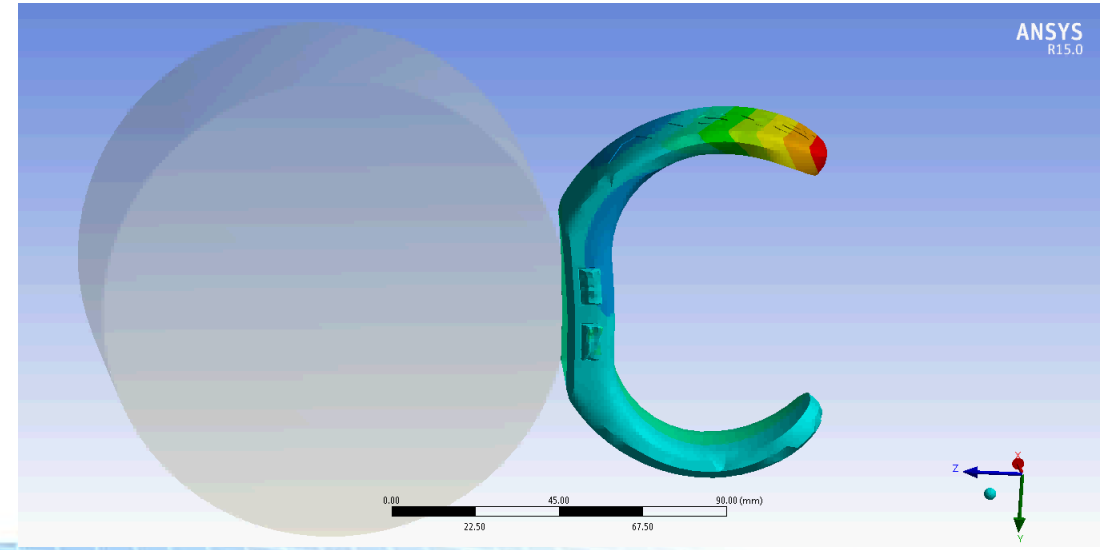
Structural and Thermal Integrity

- Dropping or hitting portable electronics is the leading cause of device failure
- The ANSYS Workbench simulation environment makes rapid virtual prototyping a reality.
- The initial design can be tested, redesigned and optimized all in a virtual environment.



Geometry from SpaceClaim

Add impact surface

Generate Mesh

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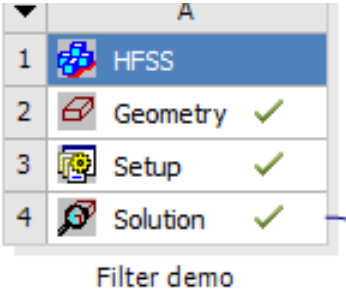
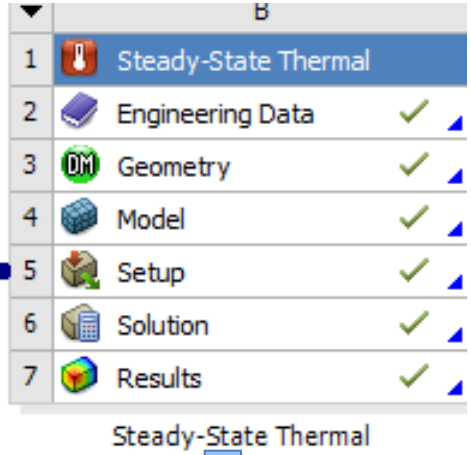
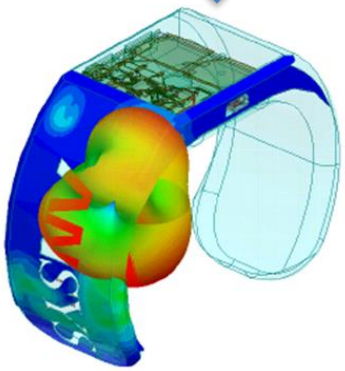
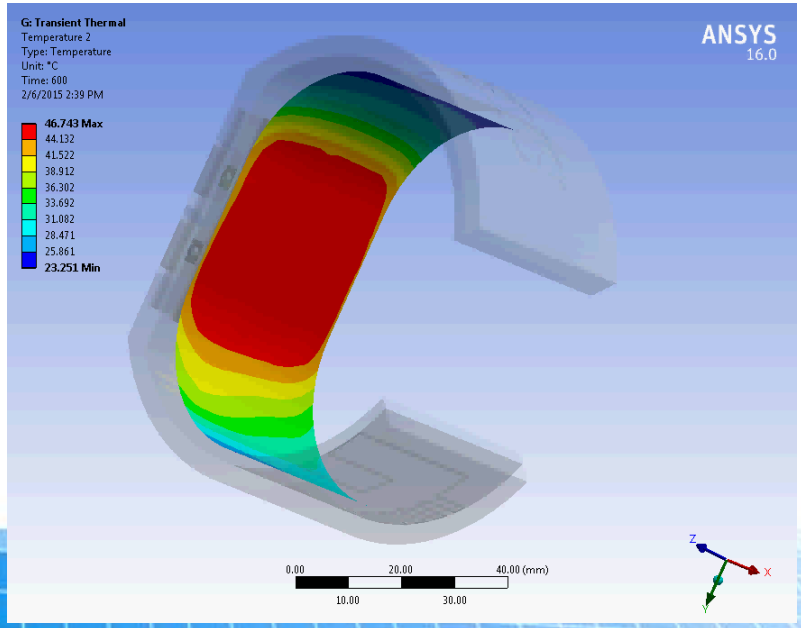
Structural and Thermal Integrity

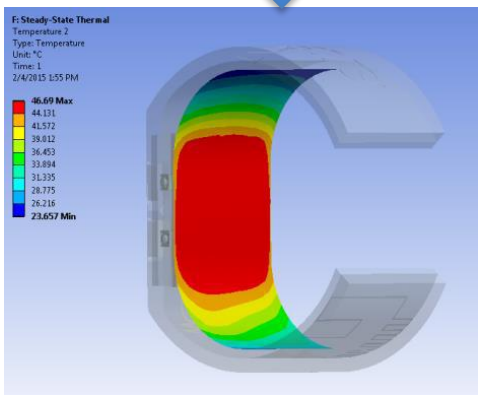
- Skin comfort is a key requirement for wearable electronics
  - This watch can be operated at maximum power for 8 hours without overheating











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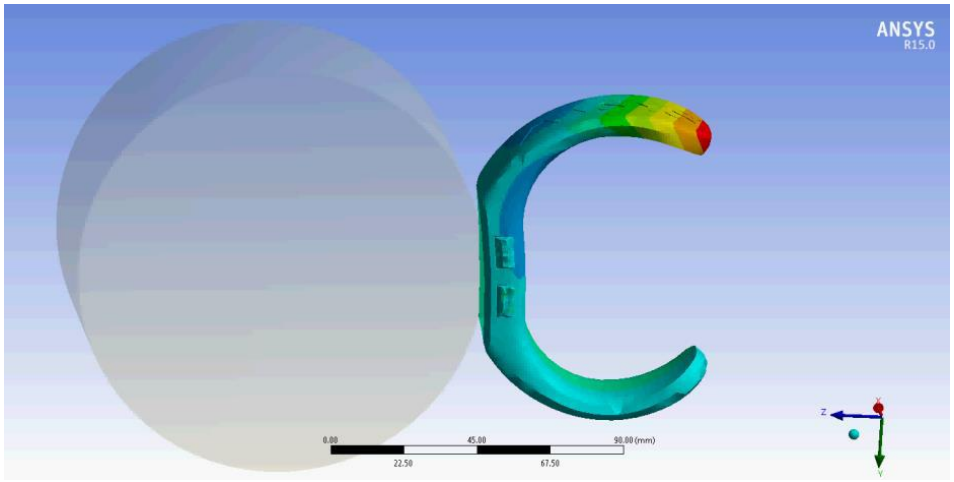
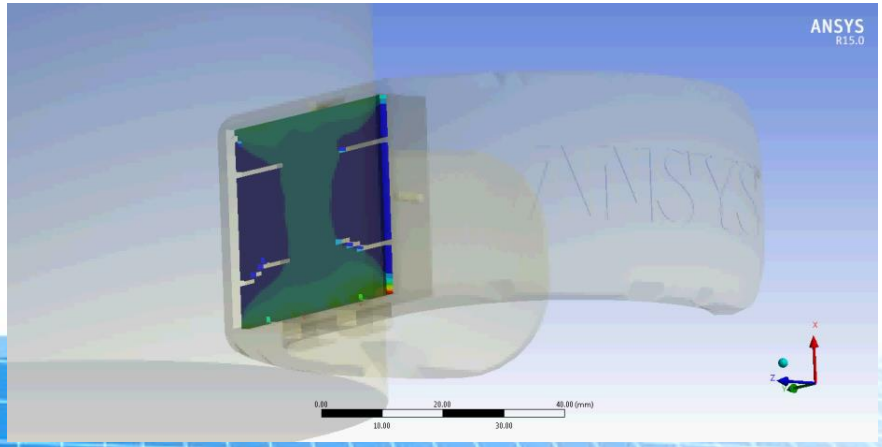
Smart Wearable Reliability

- The #1 failure mode for wearable devices is due to drop/impact.
- Simulations can help to determine the effect of an impact on the device before prototyping.
- This allows designers to improve the durability and reliability of the device.



Deformation of the ANSYS Wristband due to impact



Damage of the LCD screen due to the impact. This is prevented with design modifications.

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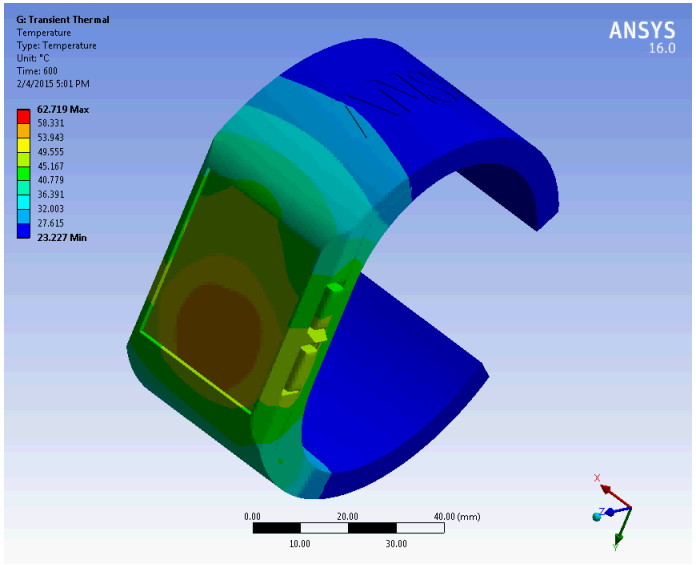
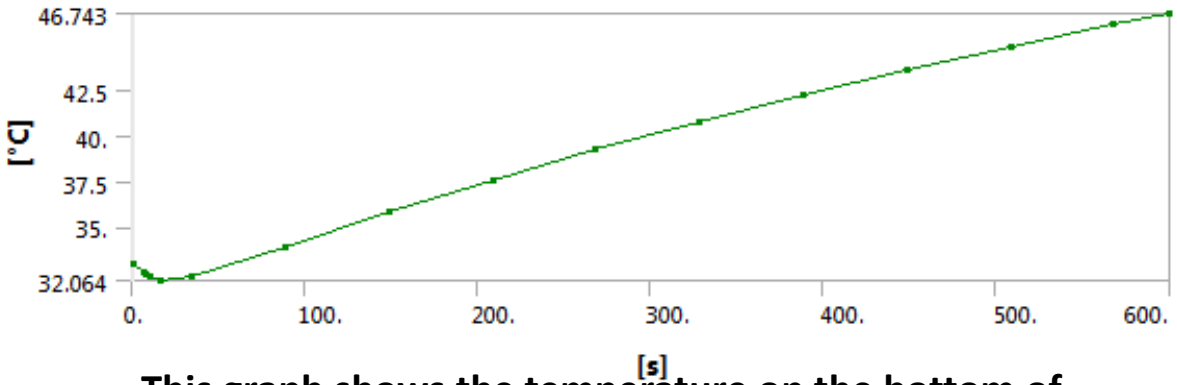
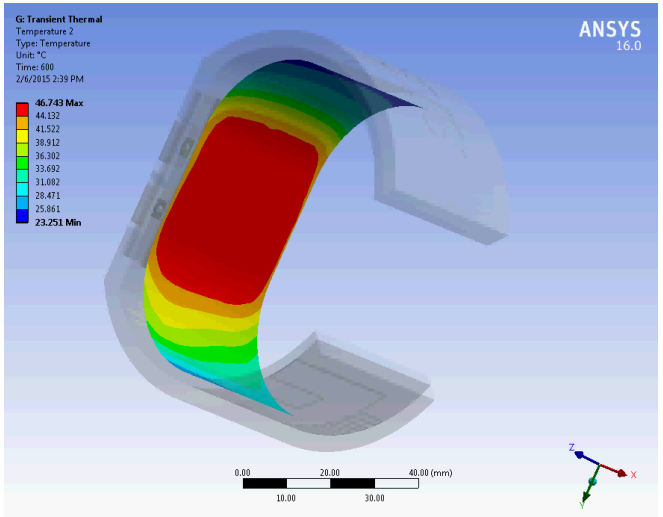
User Experience

- The ANSYS Wristband is not expected to operate at high power for extended periods of time.
- A transient simulation shows that the device can operate at high power mode for 500 seconds before the temperature exceed desirable values.
- This is deemed acceptable.





This graph shows the temperature on the bottom of the watch. It shows this watch can be run for 500s before the temperature exceeds 45C.



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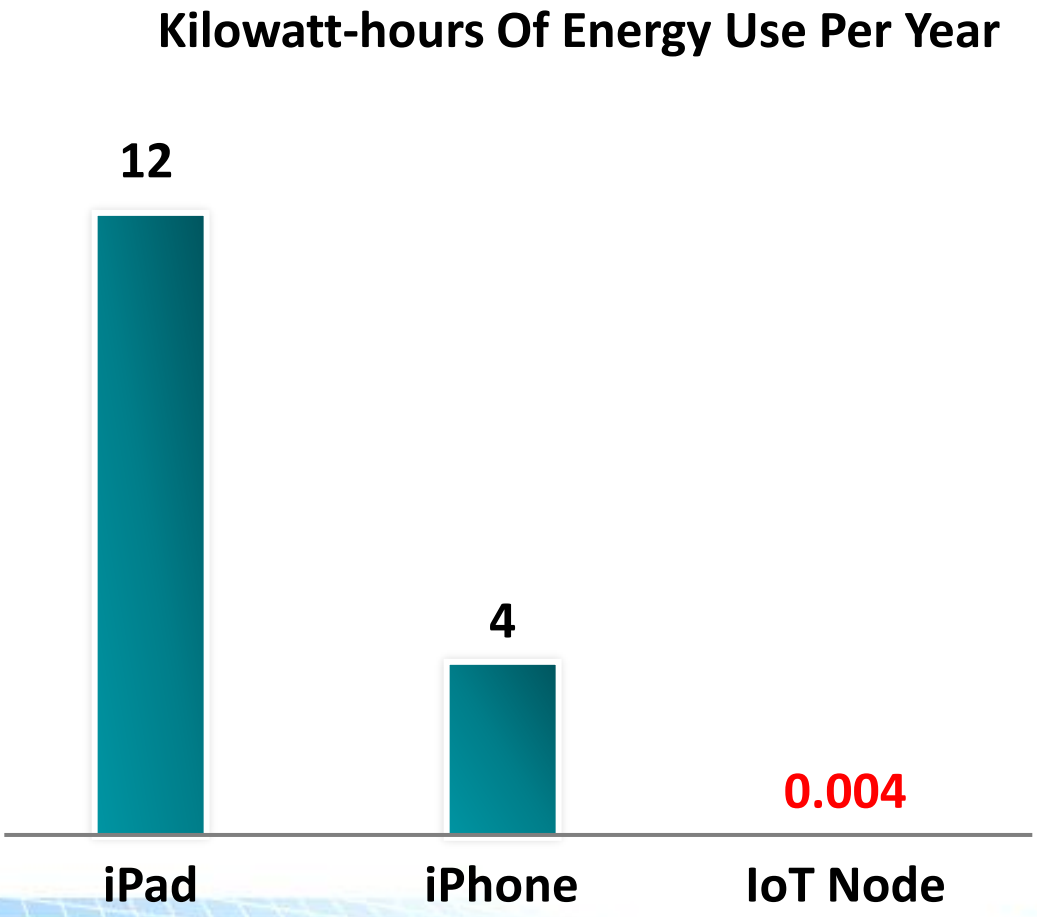
IoT Devices Will Be As Complex As A Phone But Consume A Fraction Of Energy



Sources: Electric Power Research Institute, Global Foundries

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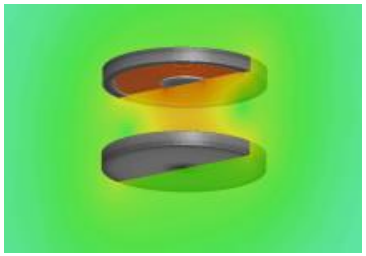
Power Efficient Electronics

- **Delivering Power Safely & Efficiently**
  - Wireless charging
  - Energy harvesting
  - Regulation compliance (e.g. SAR)



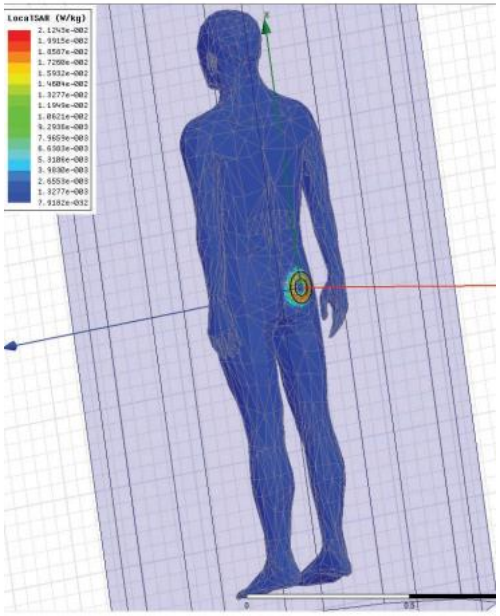
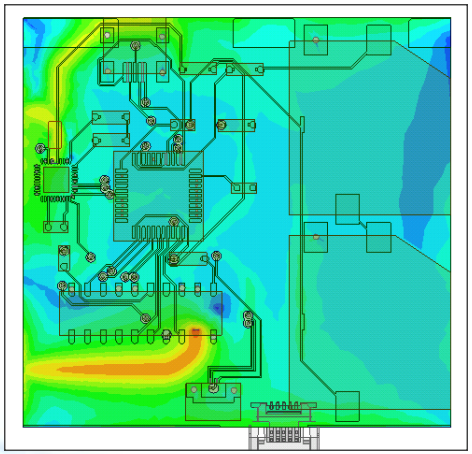


Image courtesy Medtronic, plc.

- **Reducing Power Consumption**
  - Low power IC design (e.g. 3D IC)
  - Efficient antenna design



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Smart Devices Demand Safety Critical and Secure Software

Millions of lines of safety & security critical code in smart devices

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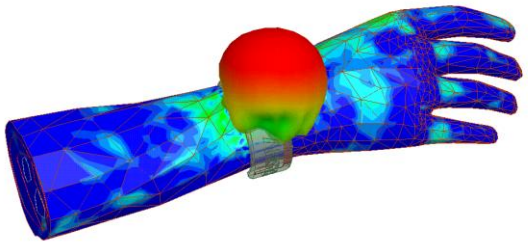
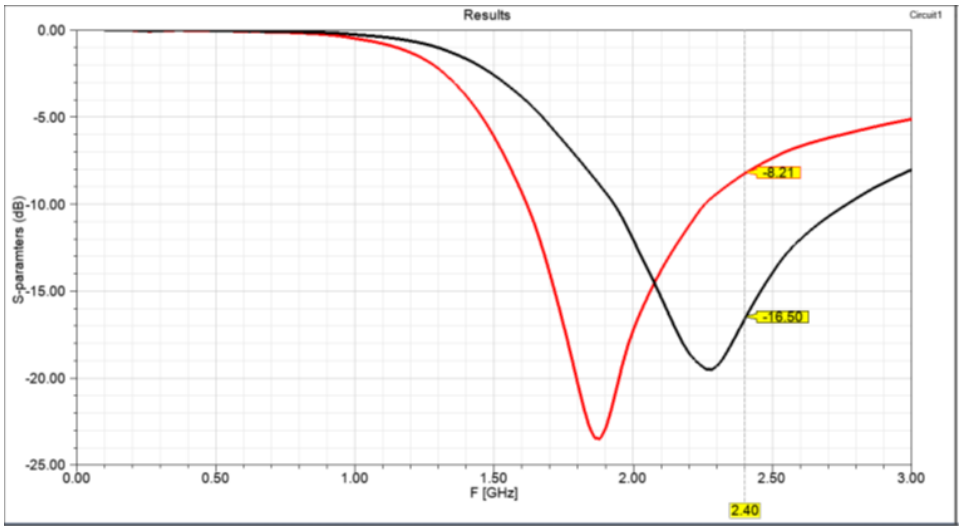
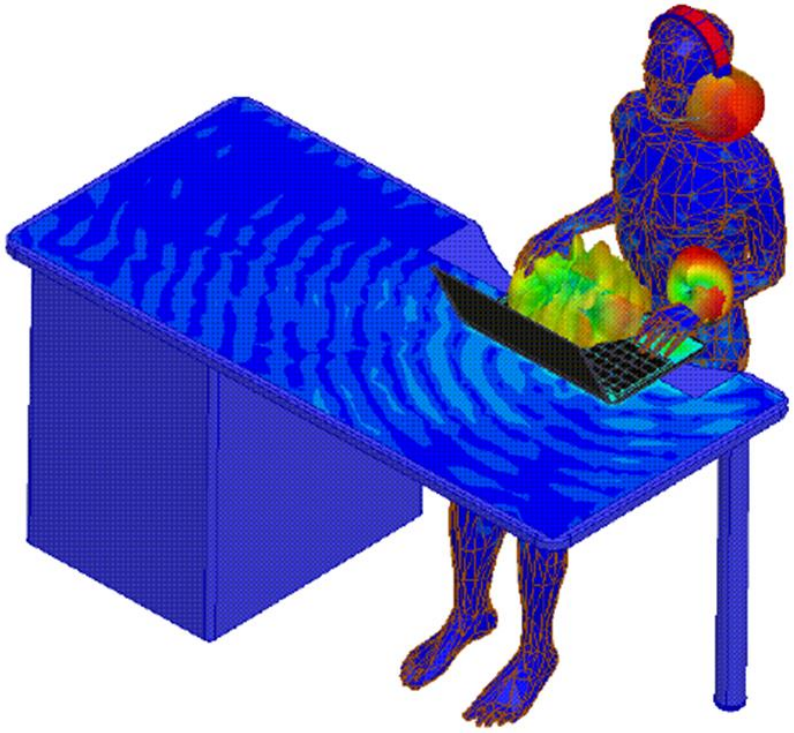
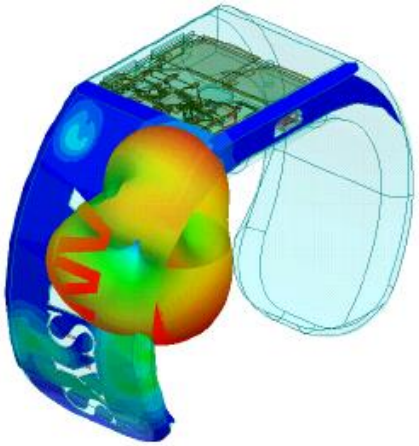
System Verification

- Simulating the whole Electrical Module
- Adding Human body model to simulation
- Simulation in the realistic noisy environment









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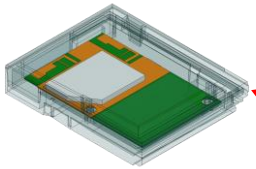
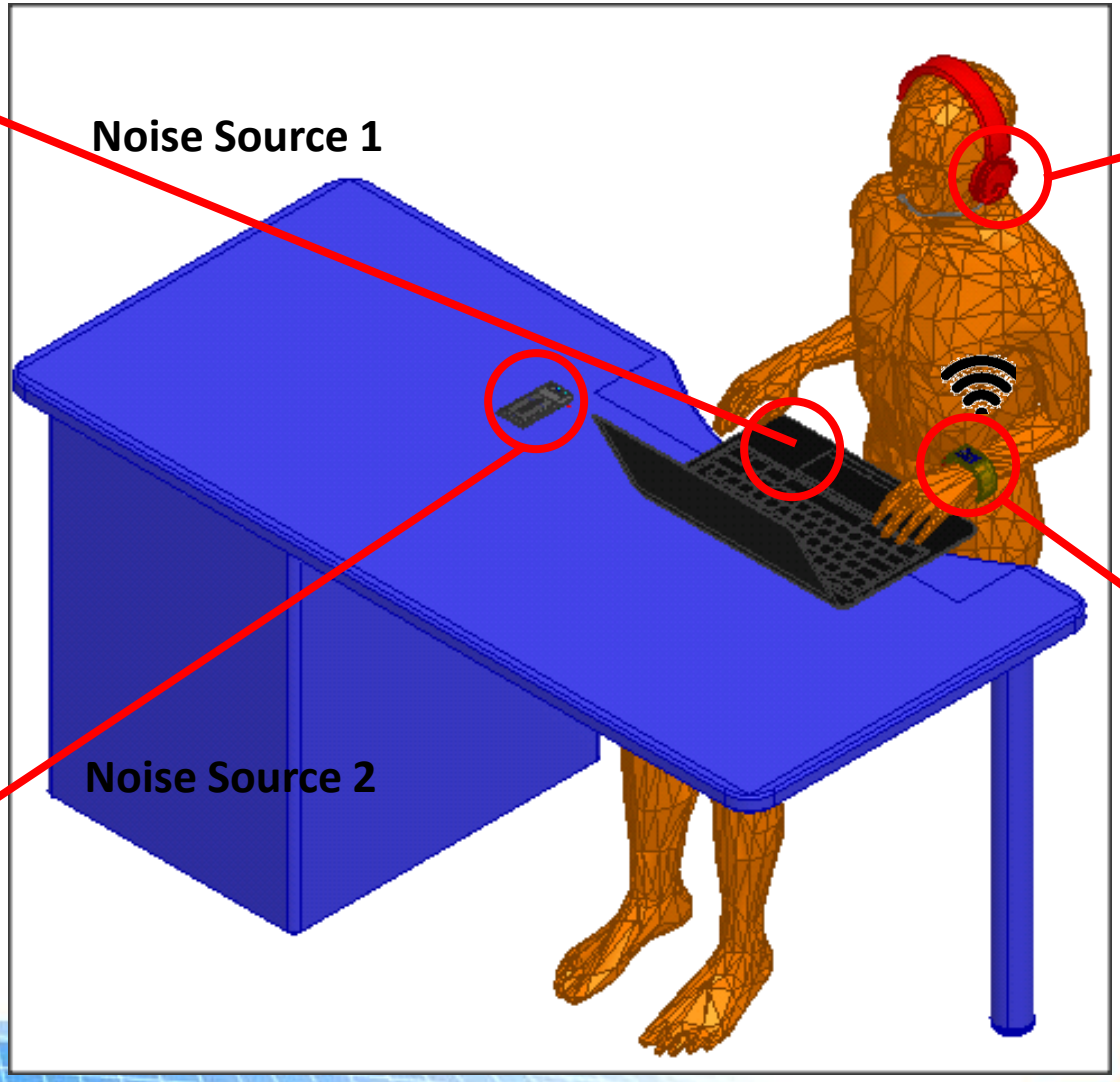
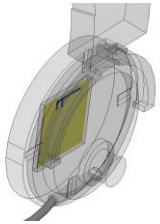
System Verification

Simulation in a Realistic Noisy Environment

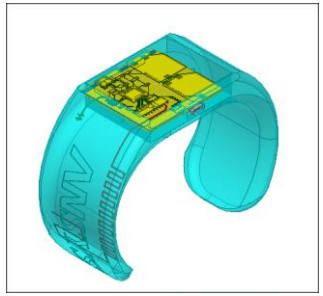


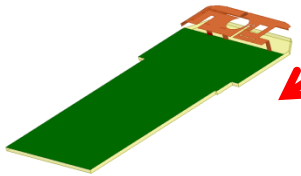


Receiver



Transmitter





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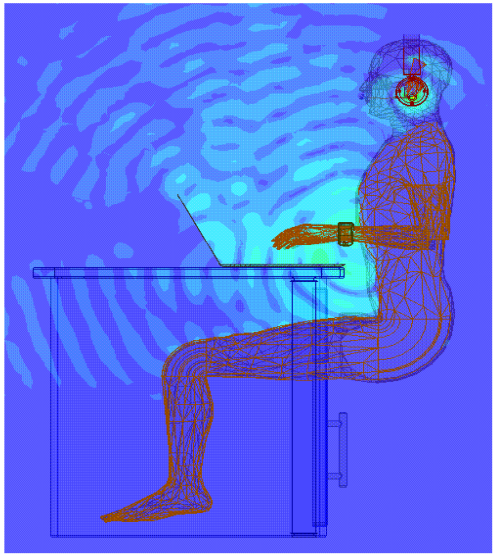
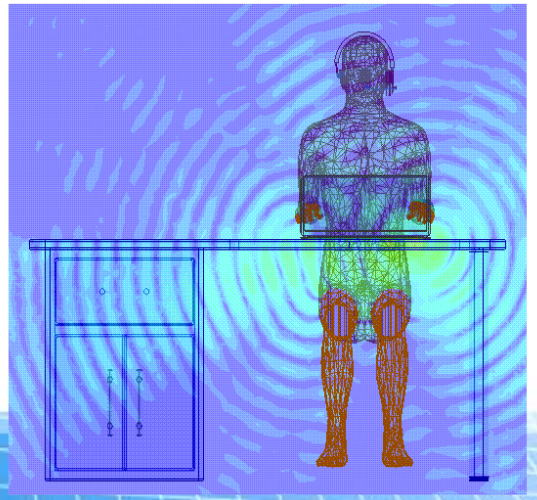
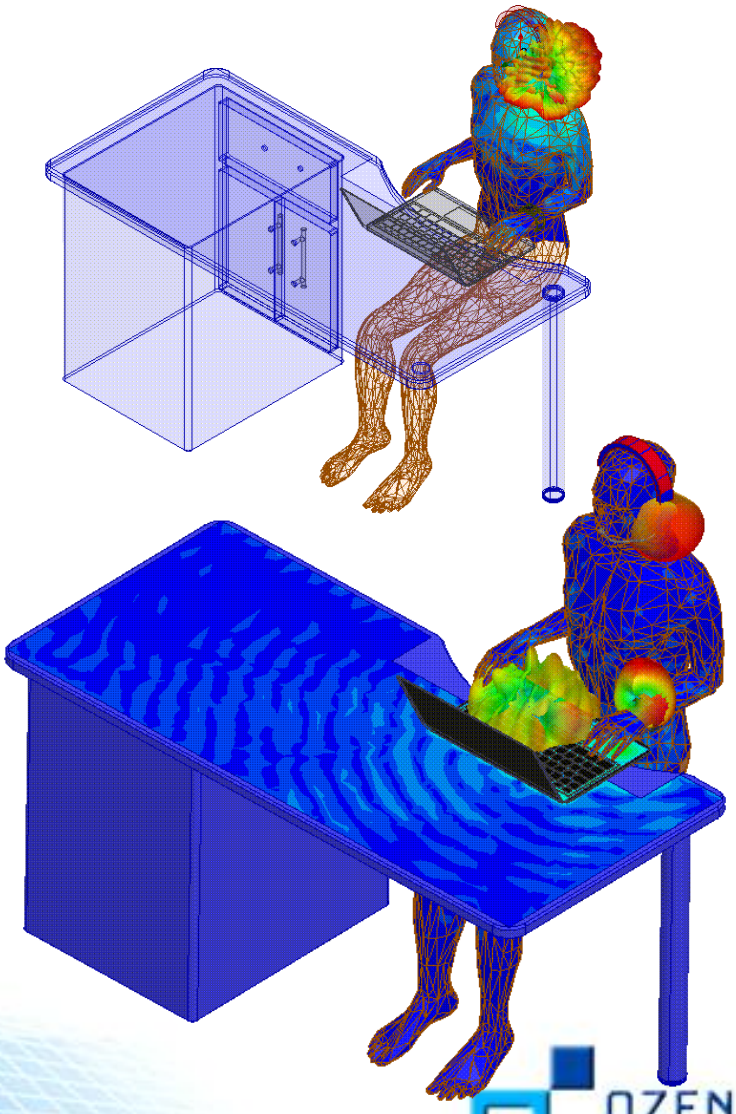
System Verification

Complete Virtual Prototyping







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Addressing Engineering Challenges With Simulation-Driven Product Development

Antennas

- EMI/EMC Compliance
- Channel Modeling
- Antenna Integration
- Signal Integrity Analysis

Power

- Static (Leakage) Power Reduction
- Dynamic Power Reduction
- Electrostatic Discharge Analysis
- Wireless Power Charging

Embedded Software

- Model-Based Design & Simulation
  - Control Systems
  - Displays
- Certified Code Generation

Structural & Thermal

- Strength Analysis
- Vibration and Drop Testing
- Thermal Analysis
- Electo-Thermal-Structure Interaction

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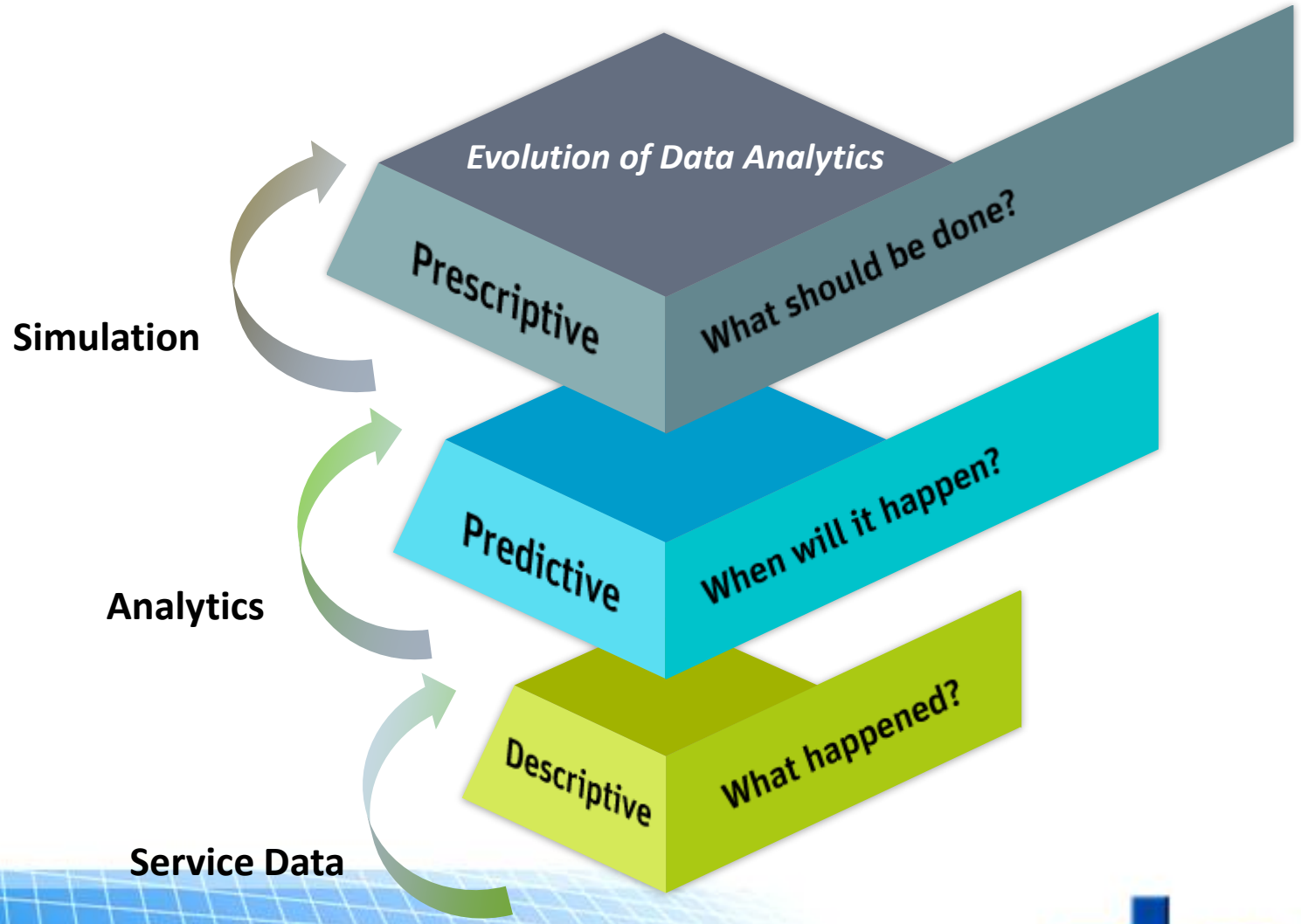
Prescriptive Analytics - The Evolution Of “Big Data” Requires Engineering Simulation



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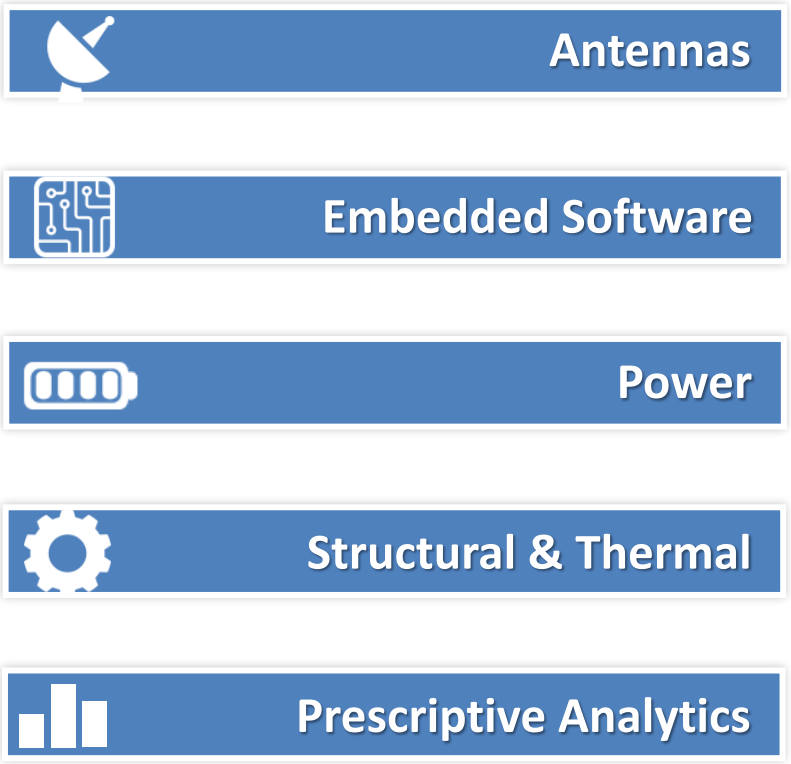
Summary: Engineering Simulation is Crucial to Designing IoT Technologies



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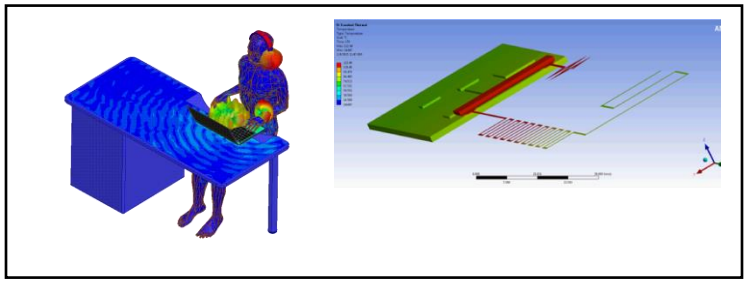
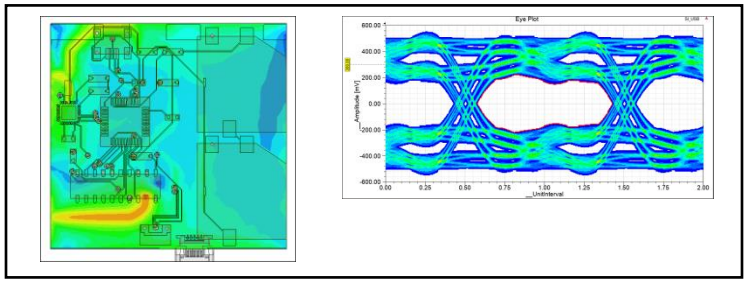
Summary: Wearable Electronics With ANSYS

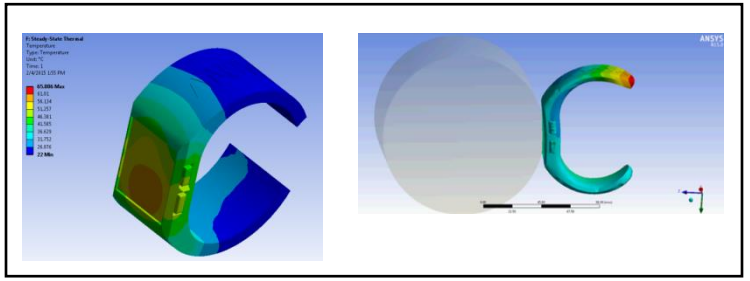
- **Antenna and Sensor Design**
  - Human Body Modeling
  - Virtual Environmental Testing



- **PCB Design**
  - Power Integrity Analysis
  - Signal Integrity Analysis



- **Structural and Thermal Analysis**
  - Impact Testing
  - User Experience
  - Manufacturing Considerations
  - Thermal



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THANK YOU FOR YOUR ATTENTION!

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