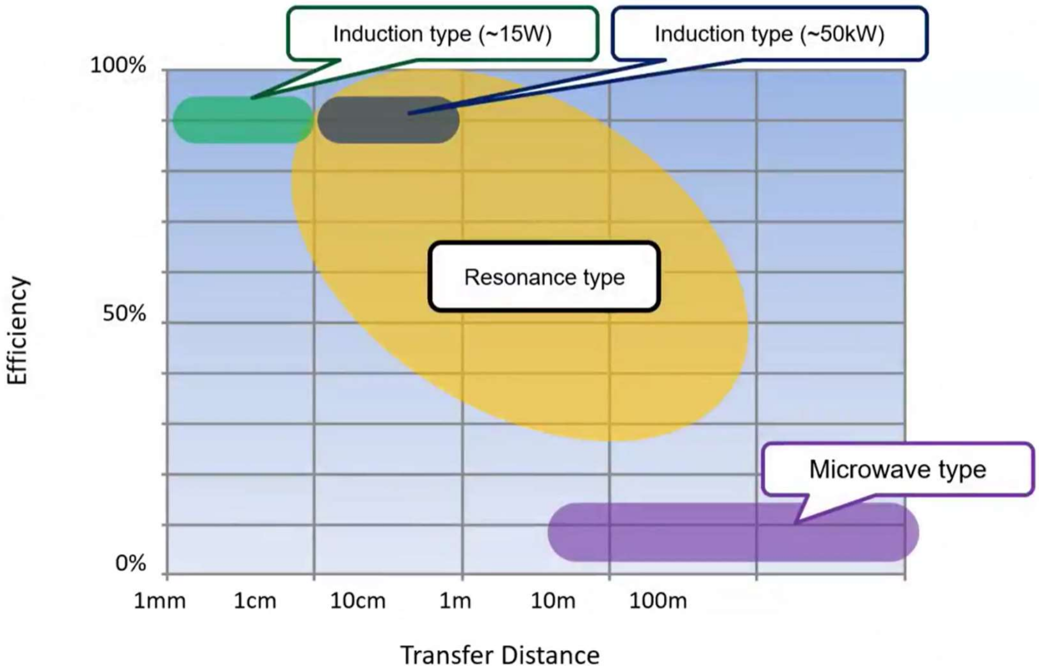
ANSYS Webnars

Wireless Power Transfer:



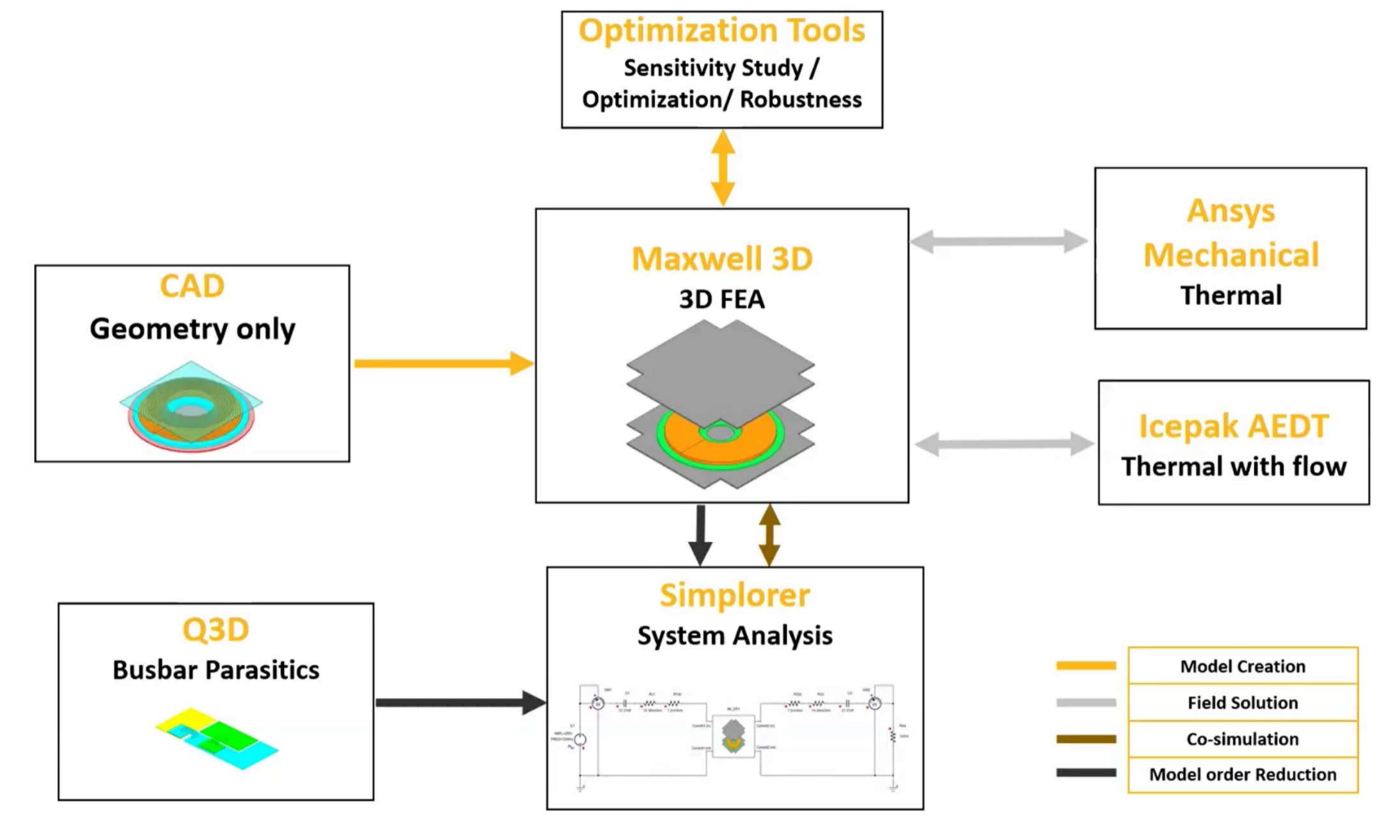
Near-Field: using inductive coupling between wires (RFID, charging, electrical vehicles)

- Operates at distances less than a wavelength of the transmission electromagnetic wave
- Resonance achieved by using external circuit capacitor
- Electric and magnetic fields can be solved separately

Far-Field: using electromagnetic radiation to transfer power

- Operates at distances more than a wavelength of the transmission electromagnetic wave
- Self capacitance among coil turns is essential
- Requires full wave solver with coupled electric and magnetic fields

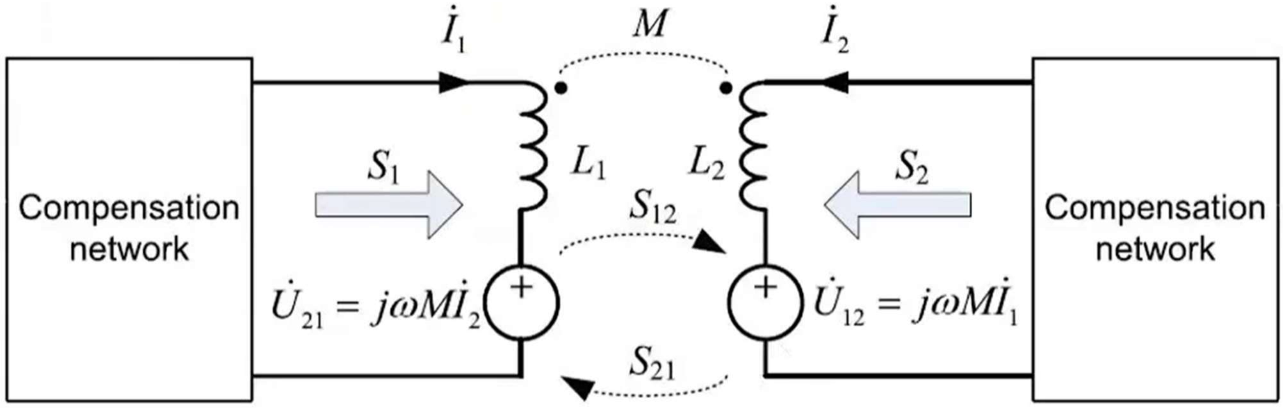
Modeling Methodology (ANSYS Solution)



Wireless Charging Workflow:

1. Model the coils and shields
    obtain RL parameters, coupling coefficients, self-inductance
2. Misalignments analyses by introducing parameters
    2 parameters are introduced:
        Slide: the shift between the centers of the coil
        Gap: the distance between the coil planes
3. Circuit Analysis/Resonance Operation Estimation
    a. Insert RL parameters extracted from Maxwell simulation and add external capacitors for resonance
        lack of the consideration of influence from different frequencies and current excitations
    b. Frequency sweep by adding Maxwell's reduced order model to the circuit in Simplorer
        Maxwell model provides RL parameters dependent on frequencies, current excitation, and misalignments

Power and Efficiency Analysis:



General Two-Coil WPT System [3]

Transfer efficiency:

$$\eta = \frac{P}{P + P_{loss}}$$

Power Loss:
1. Winding Loss: resistive loss in stranded conductors
2. Shield Loss: resistive loss in solid conductors (eddy current)
3. Core Loss: calculated by the Steinmetz equation with parameters

Coil Design Optimization:

Objective: achieve the maximum transferred efficiency

$$\eta_{\max} = \frac{k^2 Q_{Tx} Q_{Rx}}{(1+\sqrt{1+k^2 Q_{Tx} Q_{Rx}})^2}$$

where

$$Q_{Ix} = \frac{\omega L_{Ix}}{R_{Ix}}$$

Design goal: maximize the term $k^2 Q_{Tx} Q_{Rx}$ by varying 10 input variables in regard to the coil (optiSLang)

Sensitivity analysis to determine the weight of each input variable, and obtain local CoP and residuals.
Optimization with MOP solver: validate the design parameters predicted by optiSLang

Shielding Design:

Optimization of shield dimensions to minimize leakage fields

Wireless Charging with Permanent Magnets

Permanent magnets are often used for alignment and may generate strong static magnetic field, which could saturate the ferrite core and introduce eddy effects on objects while coil currents generate sin magnetic fields, affecting the RL parameters.

1. Transient Solver:
    straightforward and able to capture static and sin time-varying magnetic fields, but not considering eddy effects.
2. 3D Eddy Current Solver with permeability link method:
    require to link the permeability from magnetostatic solver, considering eddy effects, and accurate in RL param extraction.

Thermal Analysis:

Objective: study the temperature distribution of coils, ferrite plates, and aluminum shield

Icepak Procedures:

1. Define the thermal property of the material and set object temperature in Maxwell
2. EM to Icepak as heat source

ANSYS Fluent or Mechanical

Qi standard 3D Component Library:

Power transmitters reference designs and power receivers reference designs

Baseline Power Profile with single/multiple coil(s) on

extended power profile

Workflow:

1. Insert Maxwell 3D design
2. Change solution type to Eddy current

3, Drag and drop 3D components

4. Add simulation region and solution setup