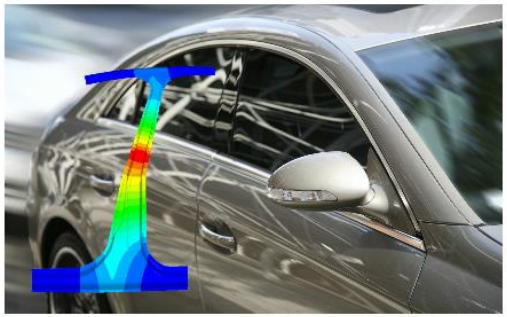
EASTERN EUROPE

Forum 2016

Leading Innovation with Virtual Prototyping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Synthesis of radiating and scattering structures using characteristic mode decomposition

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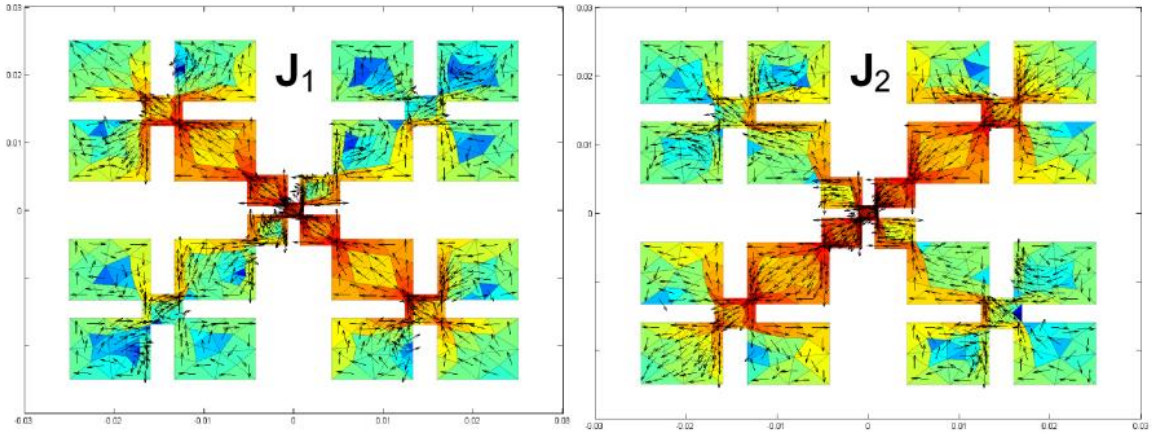

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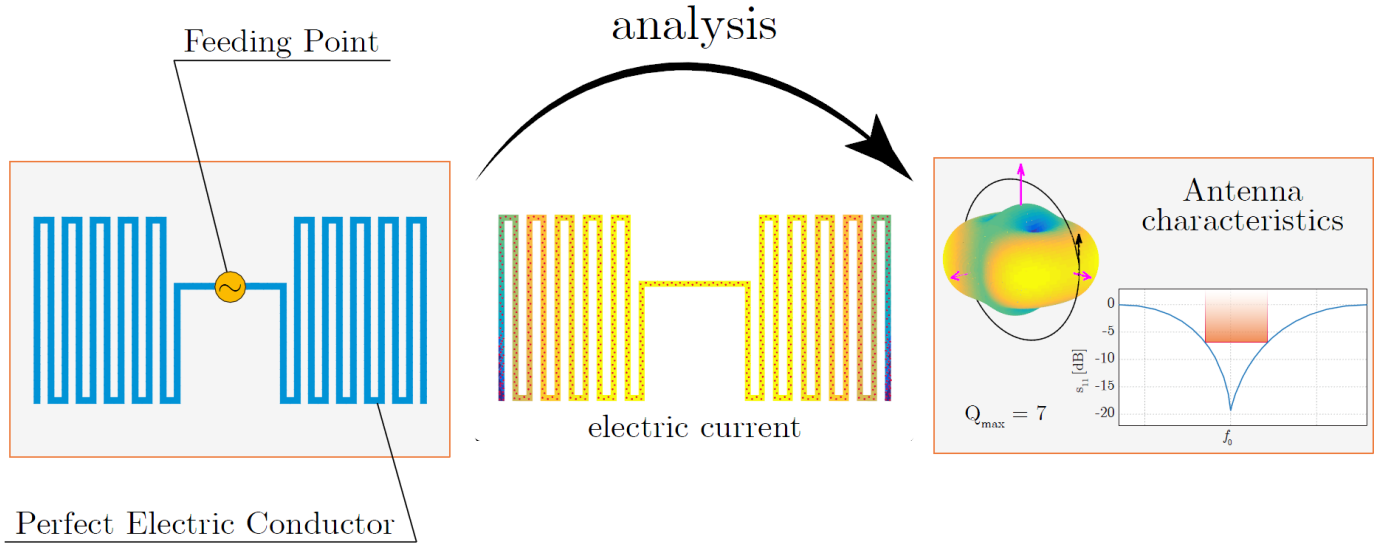
Outline

- Motivation
- Source Concept
- Characteristic Modes
- Feeding Synthesis
- Visual Antenna

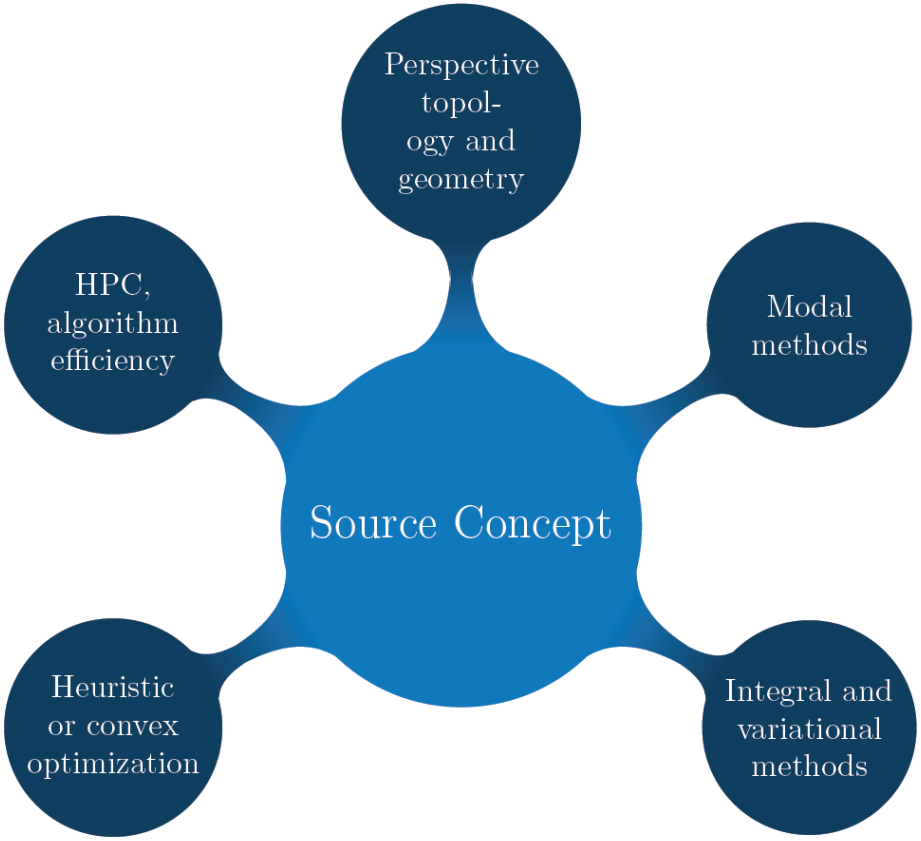
Motivation

- Understanding of principles of antenna operation.
- Using more effective antenna design techniques.
- Reduction of antenna design time.
- Our goal → antenna synthesis



Source Concept

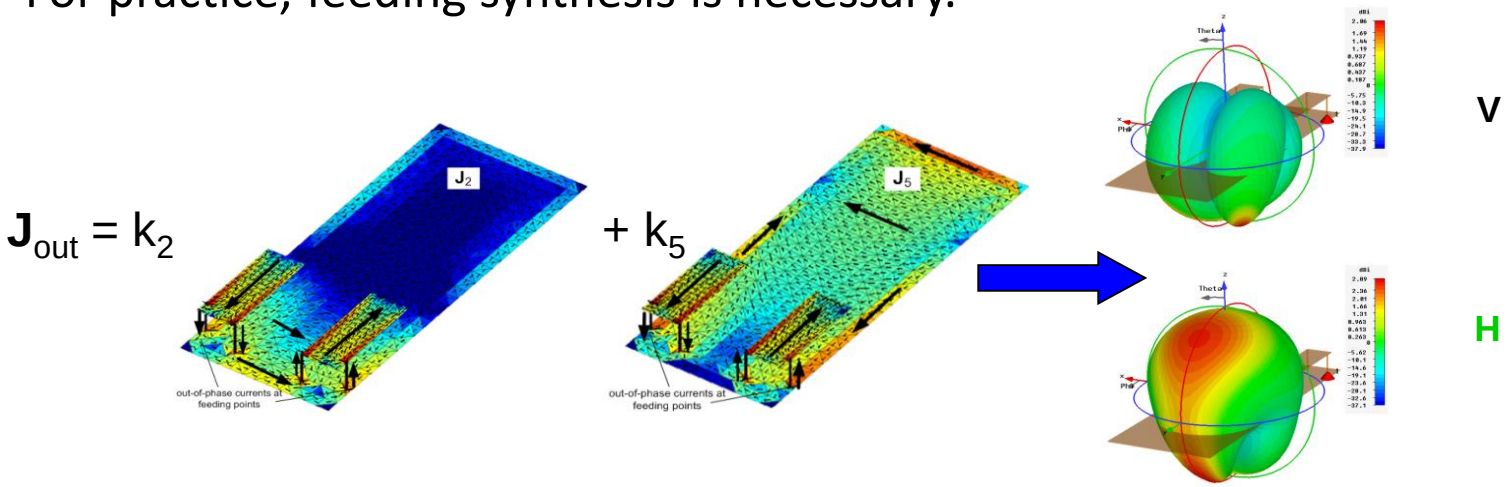
- All antenna parameters can be obtained from source current.
- Modal and spatial decomposition of source current.
- Easy optimization utilization to obtain best antenna performance.
- Optimal antenna design.



Sketch of main fields of the source concept.

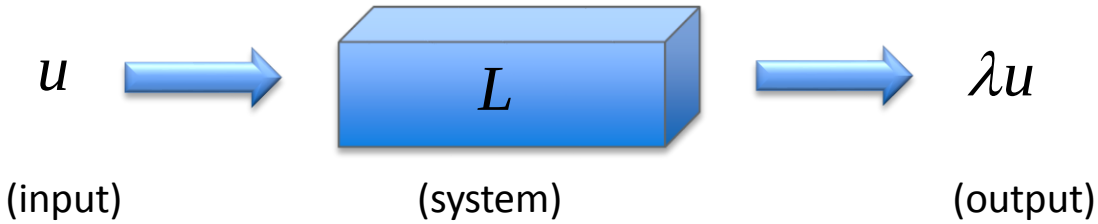
Characteristic Modes

- General approach to study arbitrarily shaped antennas.
- Only antenna shape dependent.
  - Knowledge of feeding is not necessary.
- Simple achievable design constraints identification.
  - Saves antenna design time.
- CMs are excellent for pattern synthesis.
  - For practice, feeding synthesis is necessary.



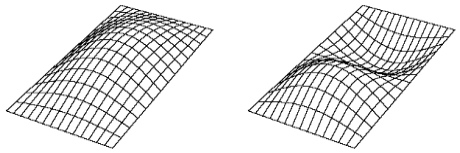
Characteristic Modes

- Modal methods - determination of set of possible resonant solutions (without feeding).

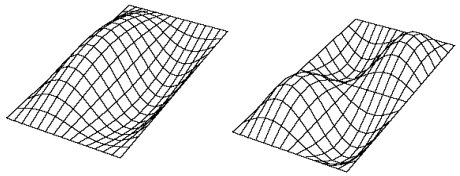


- Eigenvalue equation: $Lu = \lambda u$

system operator | eigenfunction (eigenvector) | eigenvalue



- Example of eigenfunctions:



Characteristic Modes

- Total current density on antenna with excitation E_i:

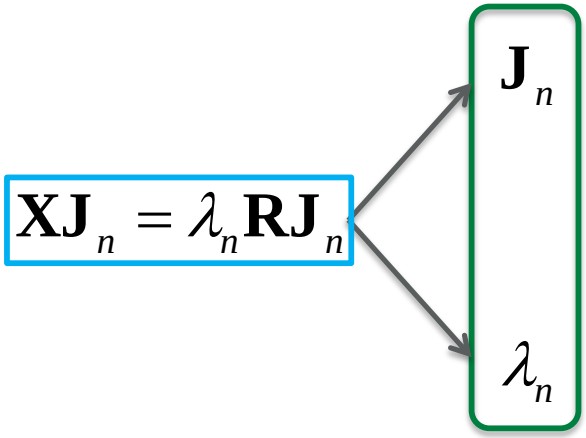
$$\mathbf{J} = \mathbf{Z}^{-1} E^i = \sum_n a_n \mathbf{J}_n$$

  - superposition of individual characteristic current modes $\mathbf{J}_n$
- Complex MoM impedance matrix: $\mathbf{Z} = \mathbf{R} + \mathrm{j}\mathbf{X}$
  - describes relations in structure
- How to obtain characteristic current modes $\mathbf{J}_n$?

Solve weighted eigenvalue equation!

$$\mathbf{X}\mathbf{J}_n = \lambda_n \mathbf{R}\mathbf{J}_n \rightarrow \mathbf{J}_n, \lambda_n$$

Characteristic Modes



- normalized characteristic current
- depends on structure shape only
- orthogonal system of currents

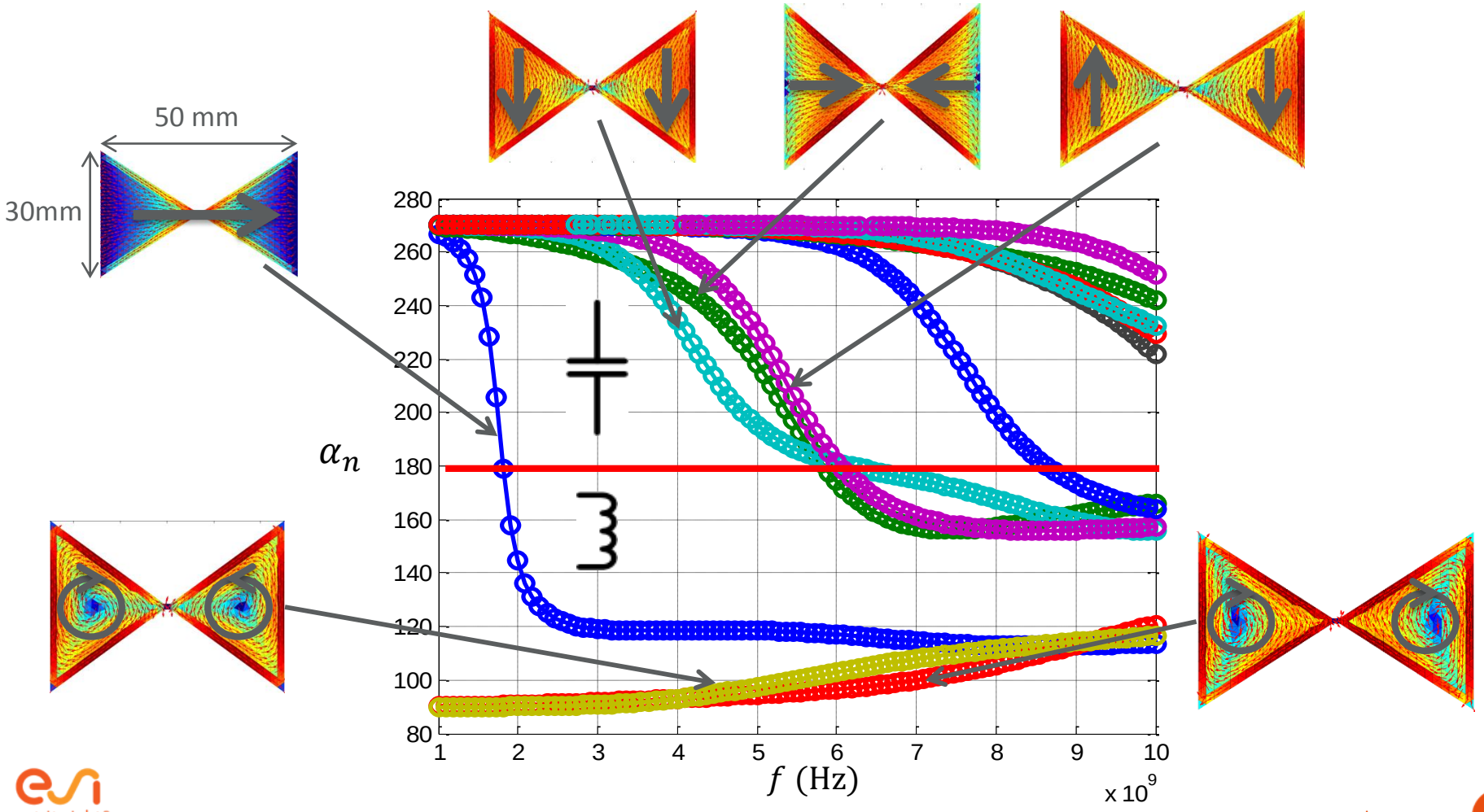
- eigenvalues represent reactive power
- = reactive power/radiated power
- = 0 means resonance of *n*-th mode

- Characteristic angles: $\alpha_n = 180° - \tan^{-1}(\lambda_n)$

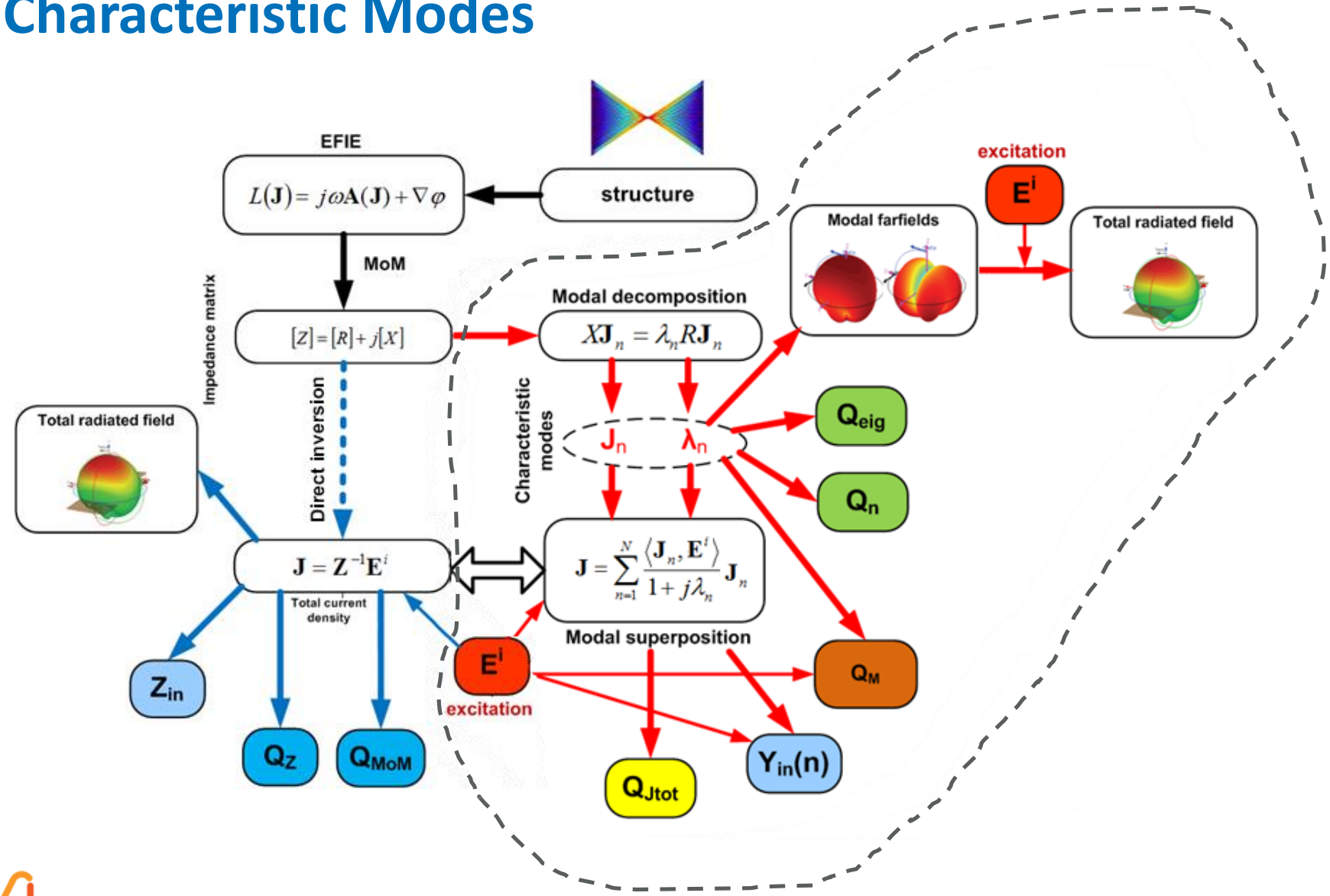
Energy	λ_n	α_n	Mode state
$W_{m,n} < W_{e,n}$	< 0	$> 180^\circ$	capacitive
$W_{m,n} > W_{e,n}$	> 0	$< 180^\circ$	inductive
$W_{m,n} = W_{e,n}$	$= 0$	$= 180^\circ$	in resonance (radiates)

Characteristic Modes

- Bow-tie dipole analysis



Characteristic Modes



Feeding Synthesis

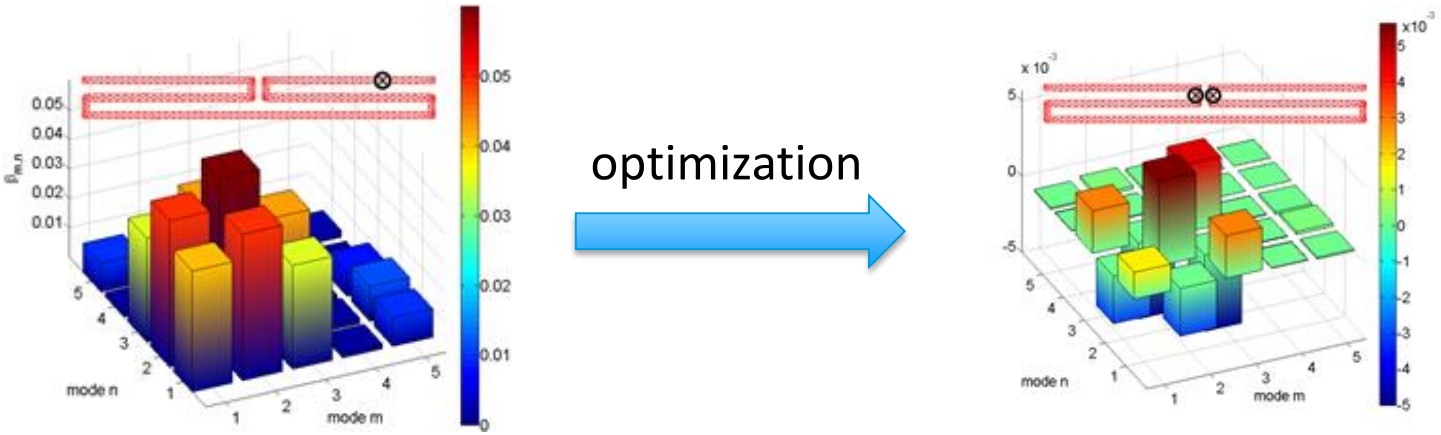
- Weighted superposition of characteristic currents

$$\mathbf{J} = \mathbf{Z}^{-1} E^i = \sum_{n=1}^{N} \frac{\langle \mathbf{J}_n, E^i \rangle}{1 + \mathrm{j}\lambda_n} \mathbf{J}_n$$

measure of *n*-th mode excitation by the E^i field (modal excitation coef.)

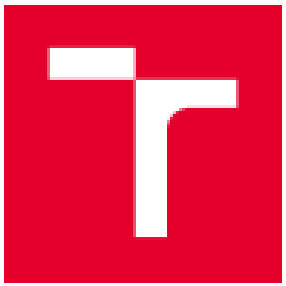
1/relative amplitude of current mode (modal significance)

- Finding positions of feeding points



The Antenna Toolbox Project 2014-2017

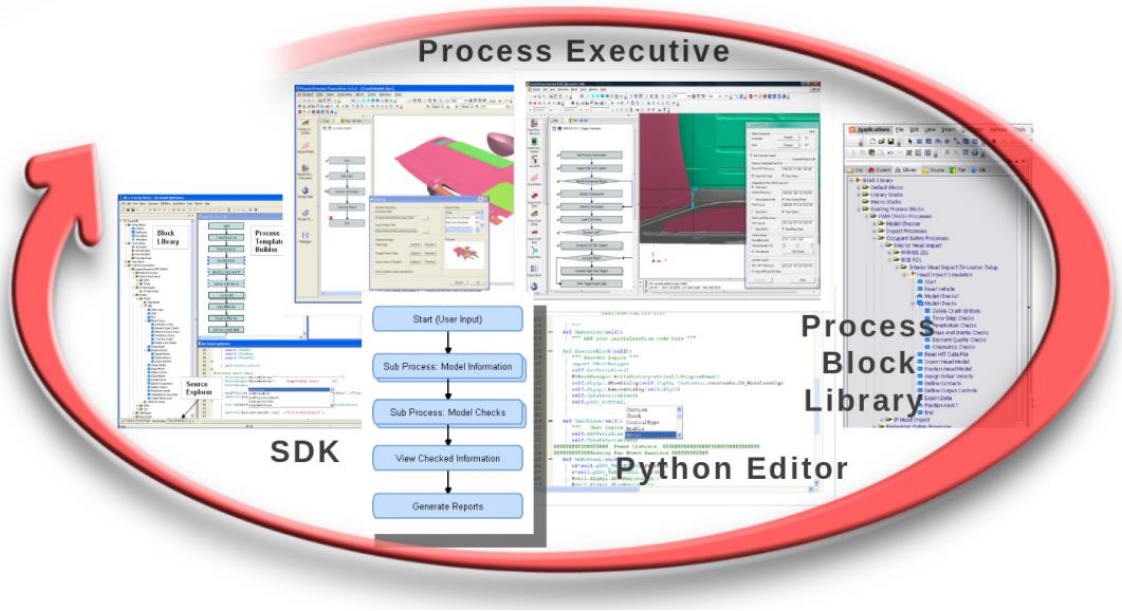
- Founding from the Technology Agency of the Czech Republic
- Main outputs: AToM - Antenna Toolbox for Matlab
  FOPS - Fast Optimization Procedures
  VisA - Visual Antenna
- Sharing academic know-how with commercial partner



Visual Antenna

Conceptual Approach

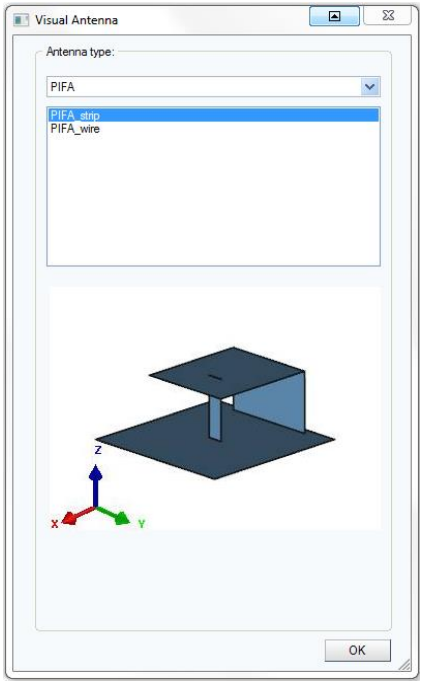
- Use of embedded Visual Process Executive
- GUI programmed in Python
- Integrated with Visual Environment: custom menu item
- Solvers in C/Fortran
- Parallel processing

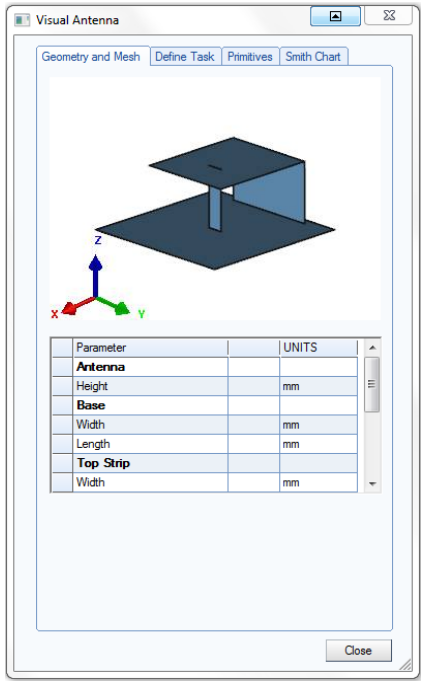


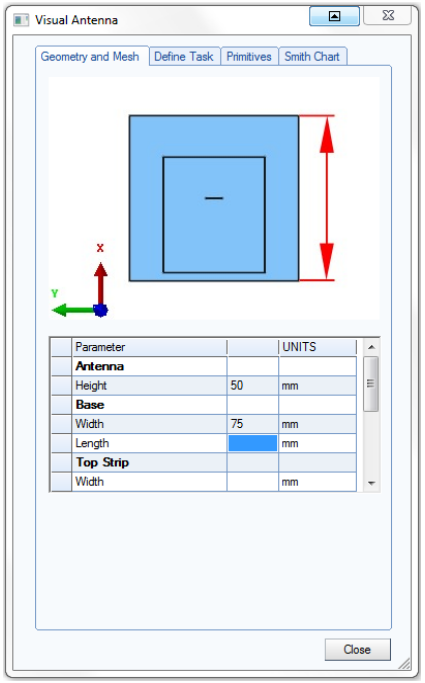
Visual Antenna

Features I

- Fully parametrized antenna models database
- Creation of geometry, scaling, combining of geometries
- Meshing





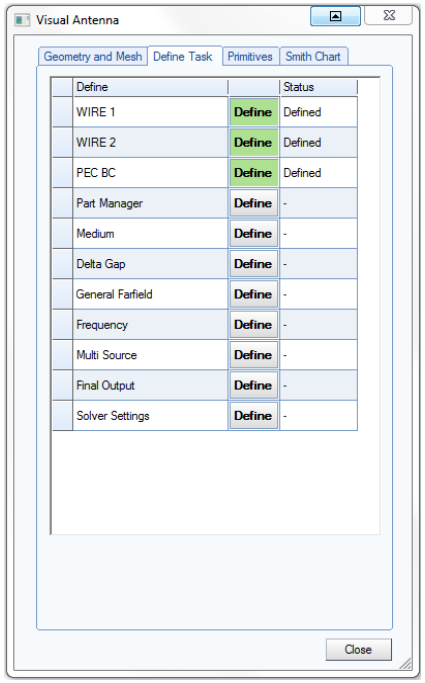


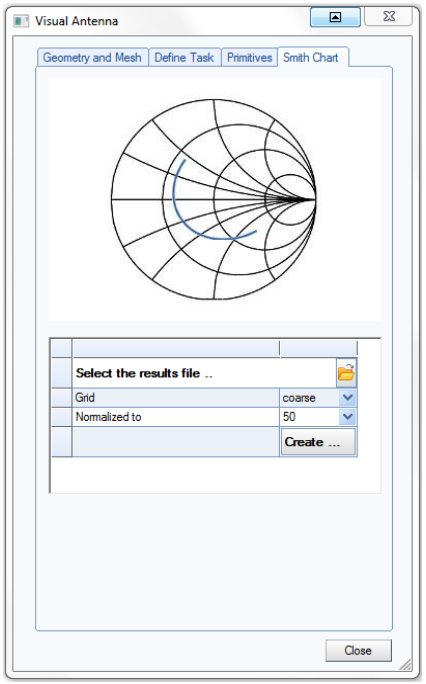
Visual Antenna

Features II

- Task setting (material properties, boundary conditions,…)
- Avoiding user errors
- Postprocessing

- 2016: TCM implementation
- 2017: parametric sweep
- 2017: optimization





THANK YOU

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