Research and Education Activities in WPT at the Budapest University of Technology and Economics

Szabolcs Gyimóthy, Péter Horváth, Sándor Bilicz, József Pávó | May 3, 2016

DEPARTMENT OF BROADBAND INFOCOMMUNICATIONS AND ELECTROMAGNETIC THEORY

Outline

Hungary joins COST WiPE

MC Members and MC Substitutes

Péter Horváth
associate professor

Szabolcs Gyimóthy
associate professor

József Pávó
full professor

Sándor Bilicz
senior lecturer

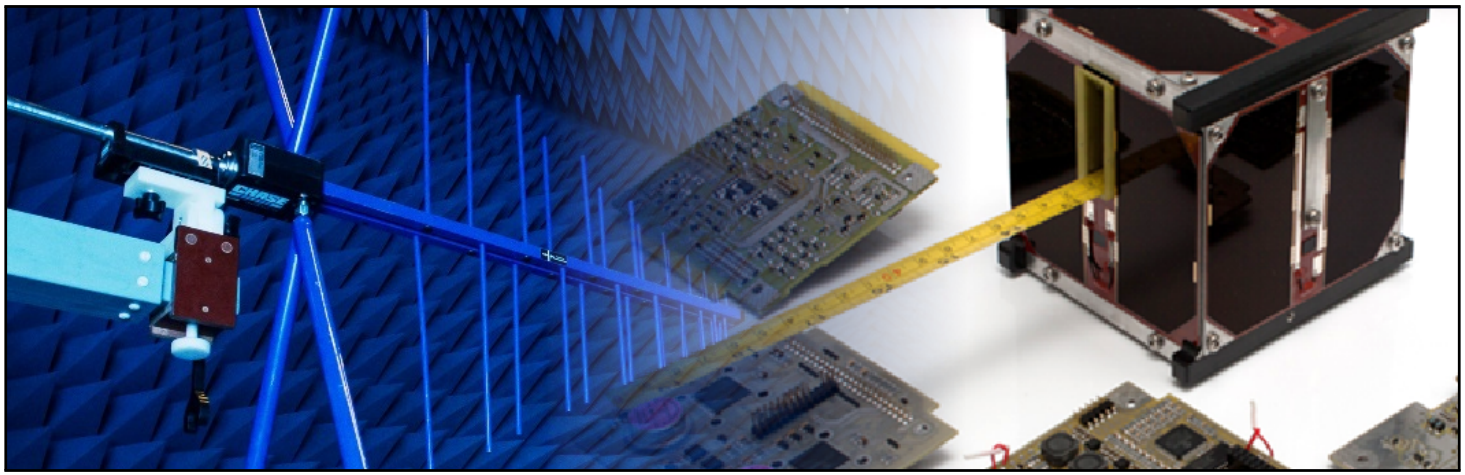
Targeted Working Groups:

- Special interest: WG2
- Additional: WG1, WG3, WG4.1, WG4.2, WG4.4, . . .

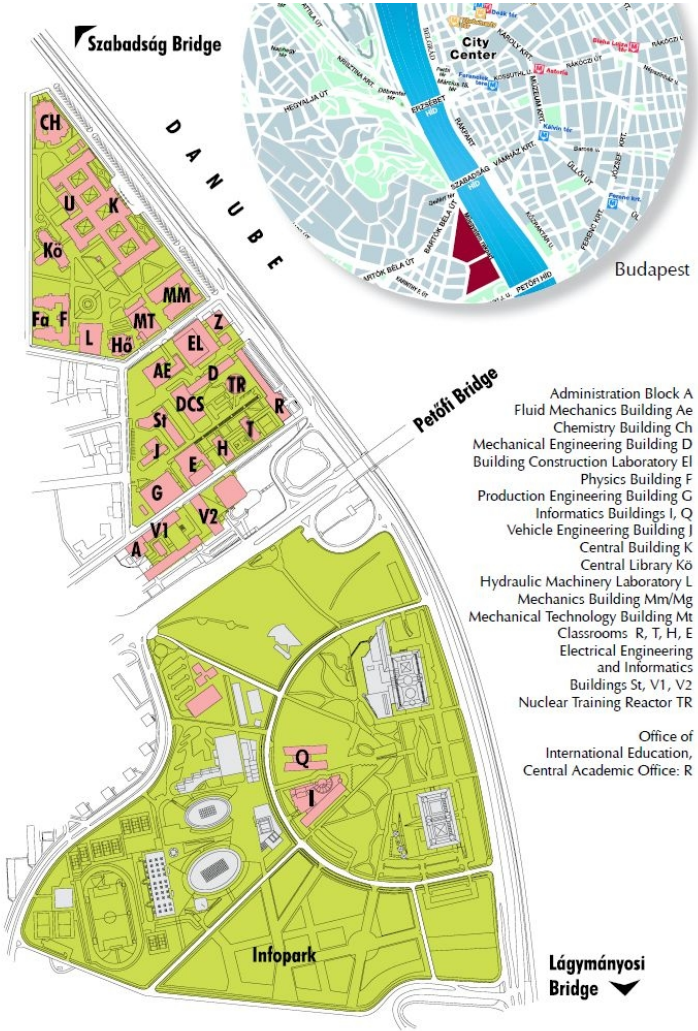
Host Institute of the Team

Budapest University of Technology and Economics

- Faculty of Electrical Engineering and Informatics
  - Department of Broadband Infocommunications and Electromagnetic Theory (head: Dr. Lajos Nagy)
    - Microwave Engineering and Telecom. Group
    - Electromagnetic Theory Group
    - Space Research Group



The University of Budapest



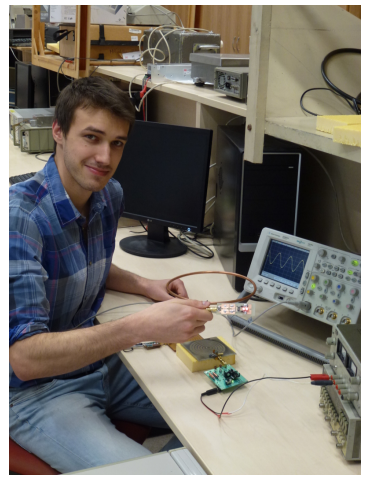
Administration Block A
Fluid Mechanics Building Ae
Chemistry Building Ch
Mechanical Engineering Building D
Building Construction Laboratory El
Physics Building F
Production Engineering Building G
Informatics Buildings I, Q
Vehicle Engineering Building J
Central Building K
Central Library Kö
Hydraulic Machinery Laboratory L
Mechanics Building Mm/Mg
Mechanical Technology Building Mt
Classrooms R, T, H, E
Electrical Engineering and Informatics Buildings St, V1, V2
Nuclear Training Reactor TR

Office of International Education, Central Academic Office: R

Education

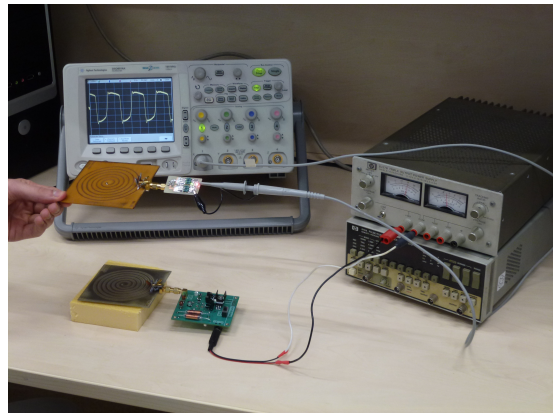
Subjects of the Department targeting (or related to) WPT

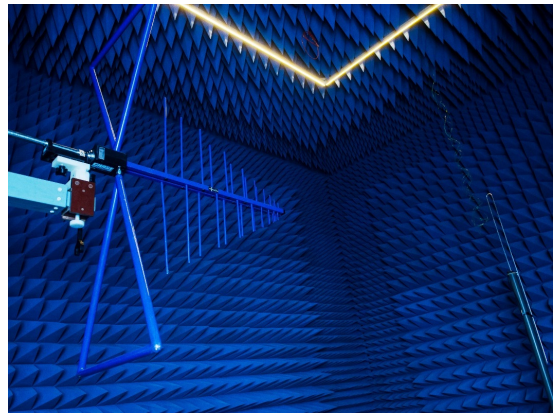
- Networks, Signals and Systems (~500 students/semester)
- Theory of Electromagnetic Fields (~400 students/semester)
- Numerical Computation of EM Fields (~20 students/semester)
- **Wireless Power Transfer** (~30 students/semester)
- Project laboratories, student competitions, PhD course. . .



Facilities at the Department

- Laboratories (Measurement & Prototyping)
  - Antennas, Wave Propagation, EMC
  - Radar and Remote Sensing
  - Optical and Microwave Telecommunications
  - Digital and Optical Communication Systems
  - Broadcasting (R&S Reference Lab.)
  - Electromagnetic Field Simulation and Design
  - Multiscale Electromagnetic Systems
  - Space Research
- Anechoic Chamber
  - $5\,\mathrm{m} \times 4\,\mathrm{m} \times 7\,\mathrm{m}$
- Computer Simulation Center
  - Comsol Multiphysics™, CST™, Infolytica™,...





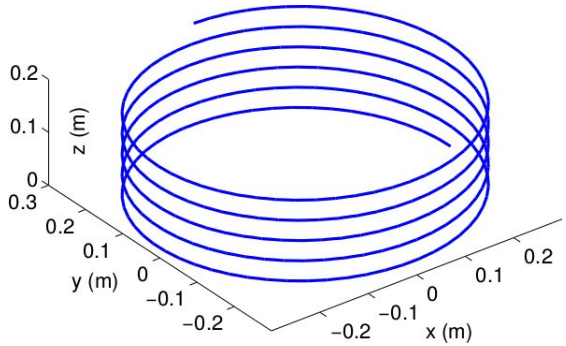
Industrial Partners

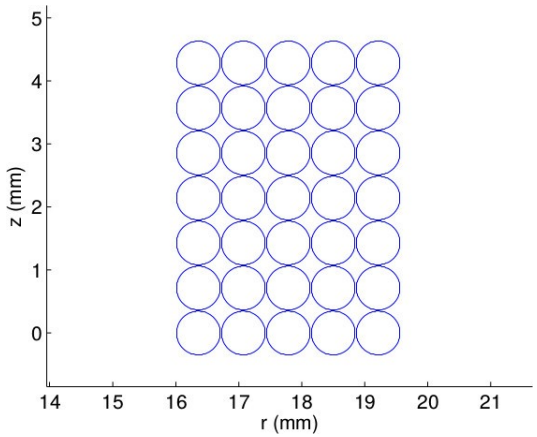
- Cooperation in WPT

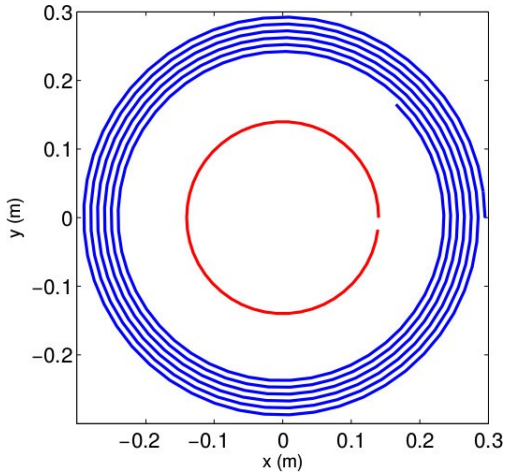
- Cooperation in related topics

Efficient Integral Equation Method for Resonator Design

$$
\begin{aligned}
\mathbf{A}_\zeta &= (\boldsymbol{M} \circ \boldsymbol{R}(\omega))\,\mathbf{I} \\
\boldsymbol{\Phi} &= (\boldsymbol{P} \circ \boldsymbol{R}(\omega))\,\mathbf{q} \\
\mathbf{0} &= r\mathbf{I}^{[n-1]} + \mathrm{j}\omega\mathbf{A}_\zeta^{[n-1]} + \boldsymbol{D}_\Phi\boldsymbol{\Phi} \\
\mathbf{0} &= \mathrm{j}\omega\mathbf{q} + \boldsymbol{D}_I\mathbf{I},
\end{aligned}
$$

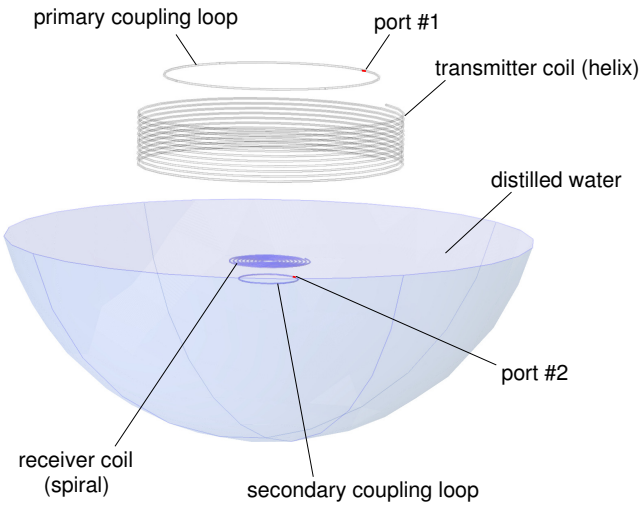


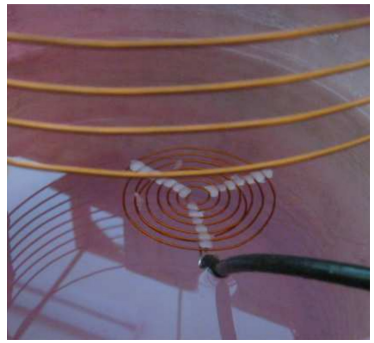


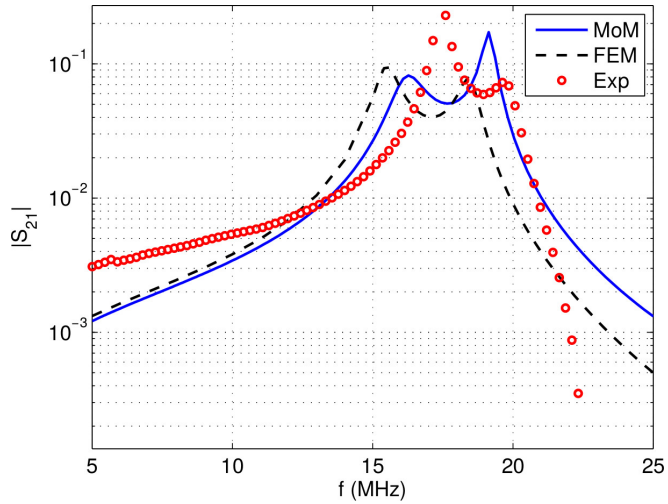


S. Bilicz, “High-frequency modelling of coils by integral formulations” *COMPEL* **34**(5) 2015

Specific IE-based Method for Modeling Heterogeneous Media

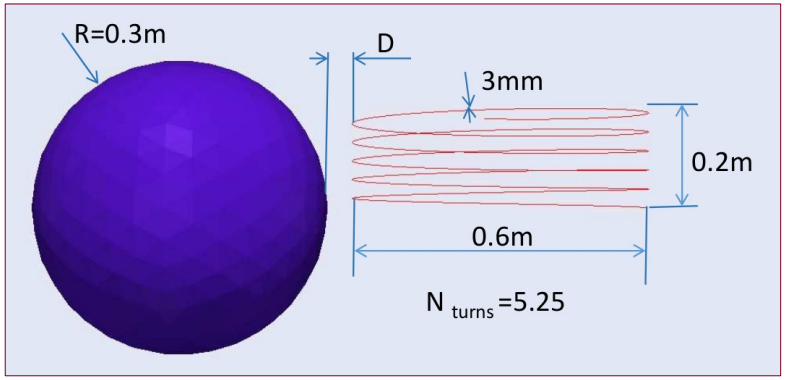


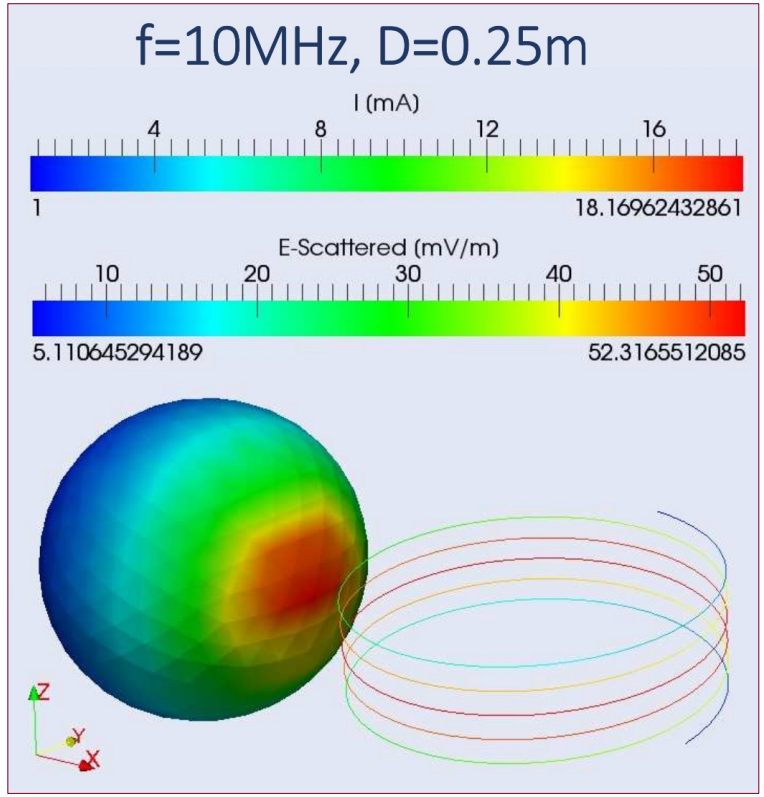




S. Bilicz, S. Gyimóthy, J. Pávó, L. L. Tóth, Z. Badics, B. Bálint, "Modeling of Resonant Wireless Power Transfer With Integral Formulations in Heterogeneous Media" *IEEE Trans. Mag.* **52**(3) 2016

FE-IE Coupling for Modeling External Objects

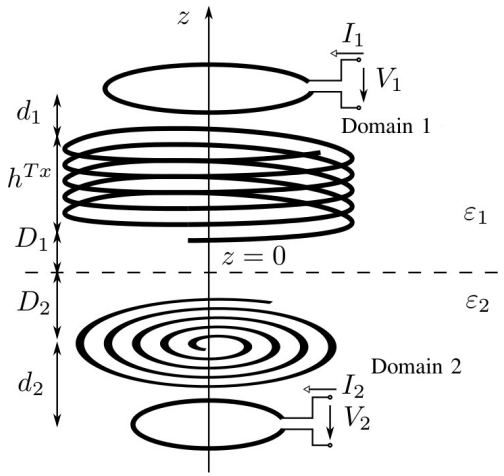




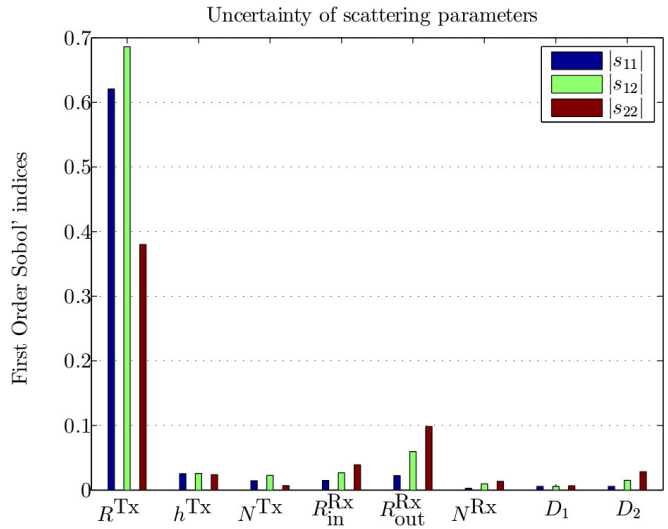
Solver	# sphere tetra 1,992		# sphere tetra: 3,987	
	Rel. run-time	# tetra	Rel. run-time	#tetra
Multi	1.0	17K	10.4	47K
Full FE	34.1	75K	91.2	135K

Z. Badics, S. Bilicz, S. Gyimóthy, J. Pávó, “Finite-Element-Integral Equation Full-Wave Multisolver for Efficient Modeling of Resonant Wireless Power Transfer” *IEEE Trans. Mag.* **52**(3) 2016

Stochastic Surrogate Models for Computing Parameter Sensitivity



	notation	nominal	tolerance
Tx	h^{Tx}	90 mm	±2.5 mm
	$R^{\mathrm{Tx}}_{\mathrm{coil}}$	111 mm	±2.5 mm
	a_{wire}	0.75 mm	
	$R^{\mathrm{Tx}}_{\mathrm{loop}}$	111 mm	
	turns (N^{Tx})	8	±0.05
	d_1	30 mm	
	D_1	100 mm	±5 mm
Rx	$R^{\mathrm{Rx}}_{\mathrm{inner}}$	2 mm	±0.2 mm
	$R^{\mathrm{Rx}}_{\mathrm{outer}}$	35 mm	±1 mm
	a_{wire}	0.5 mm	
	R_{loop}	26 mm	
	turns (N^{Rx})	7	±0.05
	d_2	7 mm	
	D_2	10 mm	±1 mm



S. Bilicz, S. Gyimóthy, J. Pávó, P. Horváth, K. Marák, “Uncertainty Quantification of Wireless Power Transfer Systems”, to be presented at WPTC2016, Poster Session II, P-2-Poster-11

Thank you