IC1301 - WiPE
Wireless Power Transmission for Sustainable Electronics

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Edinburgh

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Focus

> Antennas and propagation
> Microwaves, mm waves
> Numerical methods and electromagnetic field modelling
> Antenna, mw and EMC/EMI, measurement
> Optoelectronics, FSO
> Biomedical industriel and applications

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17 academic
13 researchers
2 administrative, technician staff
24 PhD
Czech Technical University in Prague
Department of Electromagnetic Field

» Theory of electromagnetic field
» Computational electromagnetic using analytical and numerical methods
» Electromagnetic compatibility
» Design of induction coils, antennas, microwaves circuits, RFID sensors
» New radiative (coupling) (meta)structures
» SIW
WG1

» Methods of tuning of complex input impedance of antennas for passive RFID transponders and implantable sensors for UHF and microwaves frequency bands

» Methods of space diversity for increasing of identification transponders on human body in spaces with shading of identified persons

» Low profile antennas for passive RFID transponders in UHF frequency band

» Coupling of microwave energy into human body for implantable sensors
WG2

- Analysis of electromagnetic field of induction coils and extraction their circuit parameters
- Analysis of power losses of inductive wireless power transmission
- Homogenization of inductive wireless power transmission for moving appliance
- Optimization of induction coils
WG3

» New radiative (coupling) structures, metastructures
» SIW and human body
CTU Team

» Jan Kraček, 2 (field coupling)
» Vítězslav Pankrác 2 (field coupling)
» Jan Macháč 3 (SIW, metamaterials)
» Lukáš Jelínek 2,3 (field theory, metastructures)
» Milan Polívka 1 (RFID, wearable antennas)
» Milan Švanda 1 (RFID, wearable antennas)
» Tomáš Kořínek 2,3 (experiments, antennas)
» Miloš Mazánek 2,3 (inductive coupling, antennas)
Antenna Theory – MoM/Char. Modes

\[
\mathcal{F}(J) = \frac{2\omega(W_m - W_e)}{P_r} = \text{reactive power radiated power} = \kappa = \frac{\int_{\Omega} \left[ k^2 J(r) J'(r') - \nabla J(r) \nabla J'(r) \right] \cos \frac{kR}{R} r \, dr \, dr'}{\int_{\Omega} \left[ k^2 J(r) J'(r') - \nabla J(r) \nabla J'(r) \right] \sin \frac{kR}{R} r \, dr \, dr'}
\]

- Parallelization (multiple cores / workstations), GPU computing
- Adaptive frequency sampling
Antenna Theory – MoM/Char. Modes

\[ L(J) = j \omega A(J) + \nabla \varphi \]

\[ [Z] = [R] + j[X] \]

\[ J = Z^{-1}E^i \]

Modal farfields

Modal decomposition

Modal superposition

Excitation

Total radiated field

Total current density

\[ J = \sum_{n=1}^{N} \frac{\langle J_n, J_n \rangle}{1 + j \lambda_n} E^i \]
Antenna Theory – MoM/Char. Modes

- Reactive energies of antennas, Q-factor, superposition of modal quantities

\[ -\int_{V} \frac{E \cdot J^*}{2} \, dV = P_r + j2\omega(W_m - W_e) \]

\[ -\frac{\omega}{2} \Im \left\{ \int_{V} A \cdot J^* - \phi \rho^* \, dV \right\} \]

Radiated power

\[ \frac{\omega}{2} \Re \left\{ \int_{V} A \cdot J^* - \phi \rho^* \, dV \right\} \]

Net stored power

Measurable Q-factor of radiating system

\[ Q_Z = \omega_0 \left| \frac{dZ}{d\omega} \right| \]

Expressed in terms of energy functional of source current/charge:
- Electric / magnetic energy
- Dispersion energy related to radiation
- Dispersion energy related to reconfiguration of current
Antenna & Sensor Design – electrically small
Metamaterials
prof. Jan Machac group
Biological effects of electromagnetic field

Clinical Testing of Thermotherapy

SemCAD
Industrial Applications of Electromagnetic Field

Microwave Drying and Heating

Resonant Type

Waveguide Type

Heating of Acid
EMC/EMI measurement methods

Full Anechoic Chamber
500 MHz – 120 GHz

Semi-Anechoic Chamber
80 MHz – 2 GHz

Measurement of Shielding Effectiveness of chambers and thin materials
Propagation Measurements for Satellite/HAP/UAV Systems using a Remote-Controlled Airship

» Remote-Controlled Airship
  > 9 m long
  > max. payload of 7 kg
  > CW generators at 2.0, 3.5, 5.0 and 6.5 GHz
  > spiral antennas circular polarization (LHCP)

» Receiver station on the ground – ver. A
  > broadband LHCP spiral antenna
  > portable receiver R&S PR100
  > control sw for measurements at all 4 freq.

» Receiver station on the ground – ver. B
  > 4 narrowband antennas (linear/circular polarization)
  > 4-channel receiver, SISO, 1x4 SIMO/MISO, 2x2 MIMO configurations
  > measurements at 2 GHz only (10 kHz sampling)
Penetration Loss Measurements

Measurement trials were conducted at 2.0, 3.5, 5.0 and 6.5 GHz to study signal penetration into buildings as a function of:

- elevation angle
- frequency
- receiver position within the building
- building type and surroundings


New Propagation Modelling Approach

Basic ray launching, but interactions with obstacles modelled using 3D probability radiation pattern, Diffuse scattering etc. considered while classical complicated calculations (Fresnel coef., UTD/GTD ...) avoided

Free-space optics

- Atmospheric influence evaluation
- Diversity techniques
- Ultra-short pulse research
- Beam propagation analyzes
- Indoor optics

4 FSO links of DEF
- FlightStrata G by LightPointe,
- 2 x WaveBridge 500 by Plaintree
- MRV TereScope
Laboratory

- Modular measurement chamber
Microwave spectroscopy

» Fourier Transform Microwave Spectrometer

