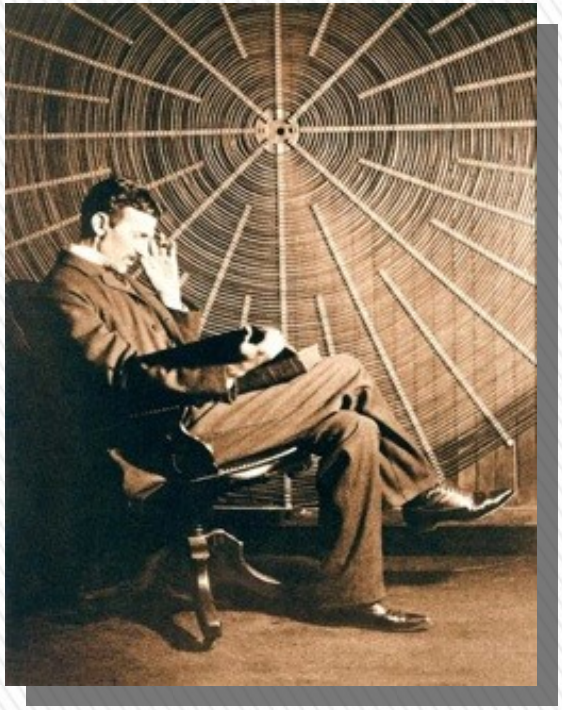

IC1301 -WiPE
Wireless Power Transmission for Sustainable Electronics

Numerical field model of near-field WPT integrated in spice environment

2016

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WIPE
COST IC1301

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Agenda

- *Motivation*: thorough simulation of magnetically coupled WPT systems
- *Assumption*: WPT chain is treated as a non-reciprocal two-port
- *Needed*: two-port parameters extracted from the EM field
- *Solution*: custom design numeric solver
- *Application*: efficiency and power distribution calculations

Numerical field model

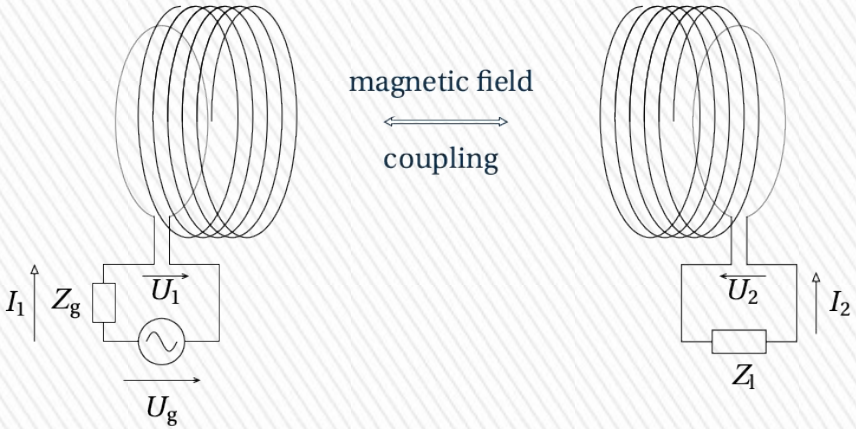
- Thin wire conductors
- To be solved: Integro-differential equations

$$A_\zeta(\zeta) = \hat{\mathbf{e}}_\zeta \cdot \frac{\mu_0}{4\pi} \int_L \frac{I(\zeta')\,\mathrm{d}\zeta'}{\chi(\zeta,\zeta')} \mathrm{e}^{-\mathrm{j}\beta\chi(\zeta,\zeta')}$$

$$\varphi(\zeta) = \frac{1}{4\pi\varepsilon_0} \int_L \frac{q(\zeta')\,\mathrm{d}\zeta'}{\chi(\zeta,\zeta')} \mathrm{e}^{-\mathrm{j}\beta\chi(\zeta,\zeta')}$$

$$0 = \frac{\mathrm{d}I(\zeta)}{\mathrm{d}\zeta} + \mathrm{j}\omega q(\zeta)$$

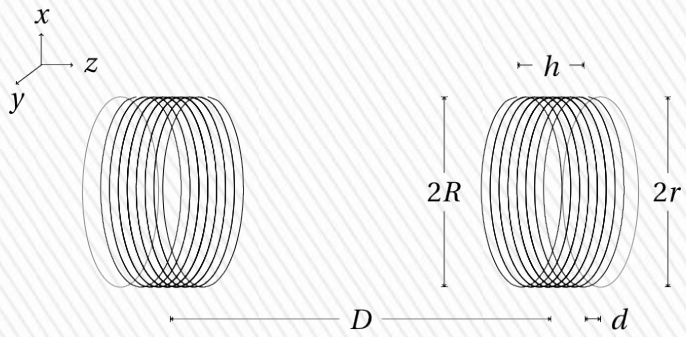
$$z_\mathrm{i} I(\zeta) = -\frac{\mathrm{d}\varphi(\zeta)}{\mathrm{d}\zeta} - \mathrm{j}\omega A_\zeta(\zeta)$$



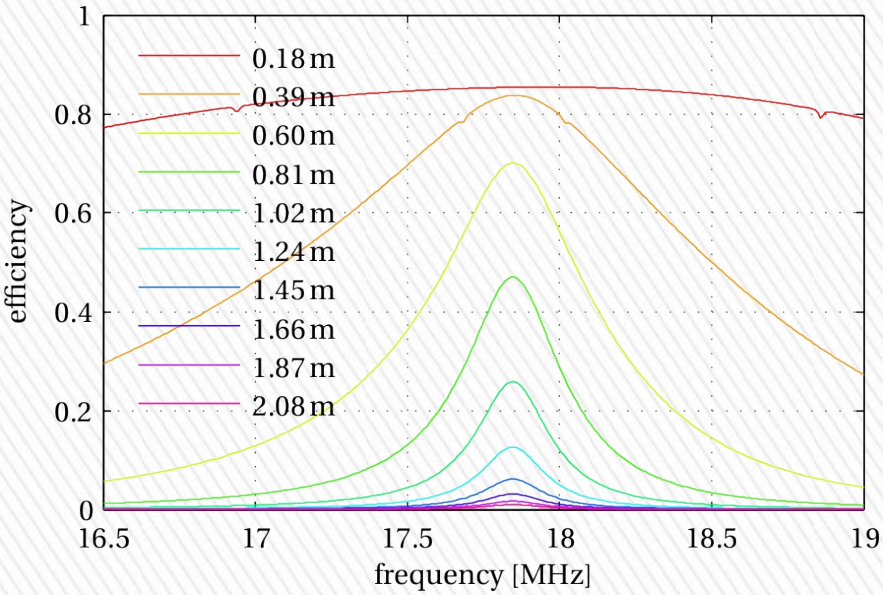
- Knowing the terminations, efficiency can be calculated.

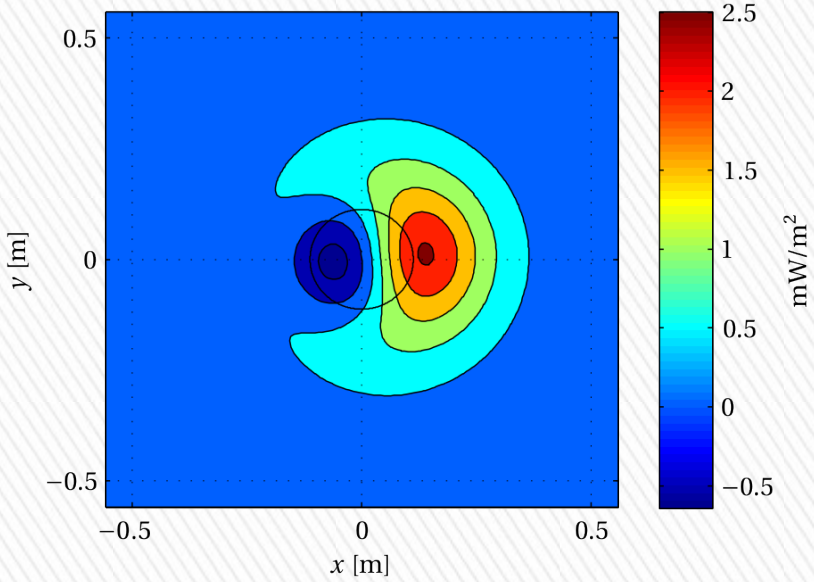
$$\eta = \frac{P_\mathrm{l}}{P_\mathrm{g}} = \frac{\mathrm{Re}\left\{-\frac{1}{2}U_2 I_2^*\right\}}{\mathrm{Re}\left\{\frac{1}{2}U_\mathrm{g} I_1^*\right\}}$$

Results of classical WPT chains



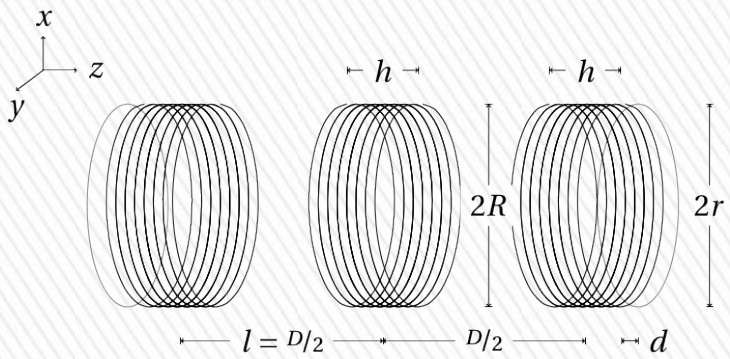
Par.	D	d	R	r	h	turns	$f_{res.}$
Val.	0.5 m	1 cm	11.25 cm	11.25 cm	≈ 8 cm	8	17.84 MHz



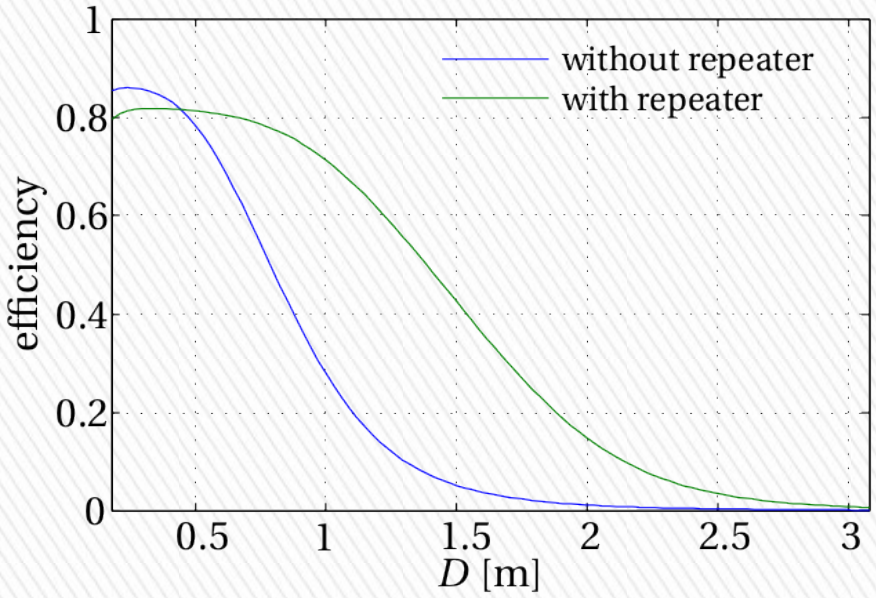


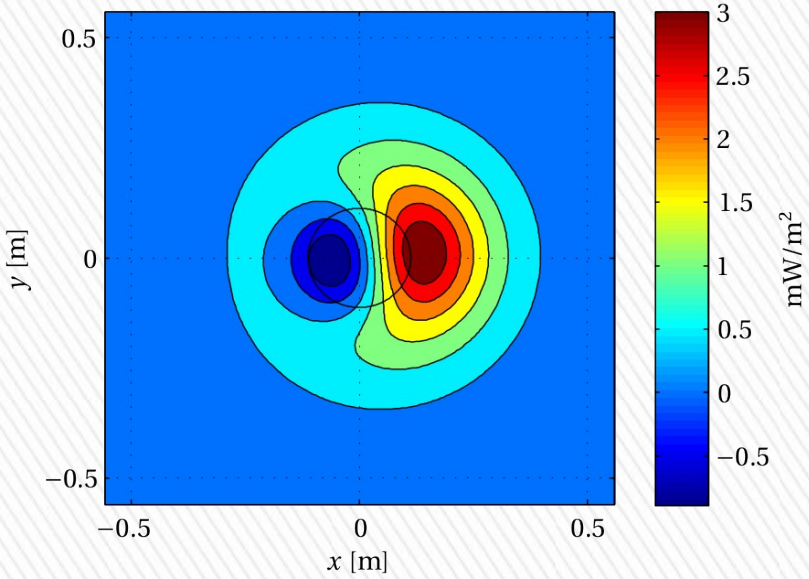
- Efficiency as the function of frequency and distance.
- Power density distribution
- in the $z = D/2$ plane.

Results with repeater included



» nominally D = 1 m

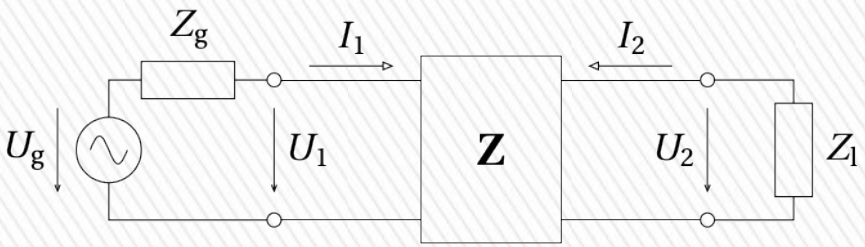




» Efficiencies compared as the function of distance.

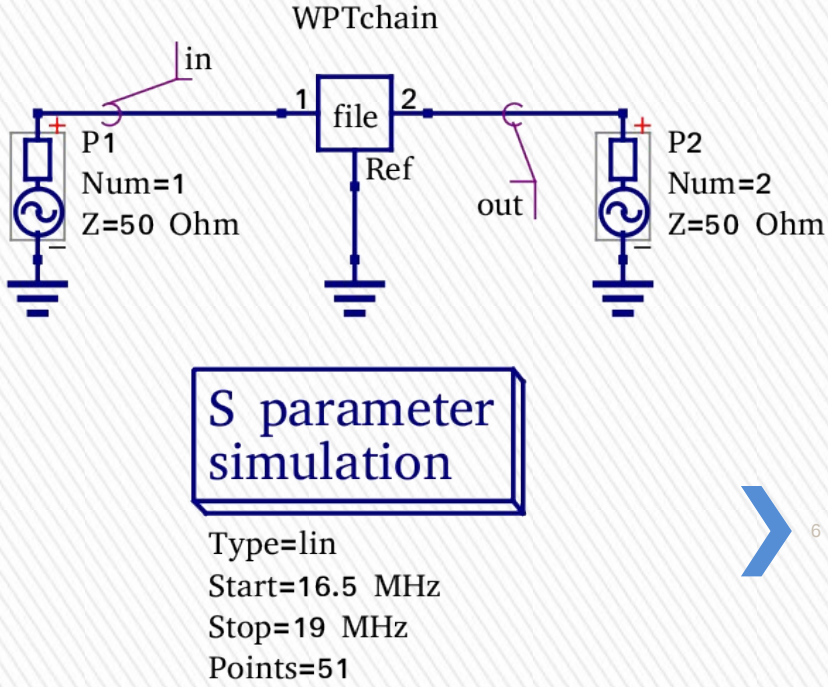
» Power density in the $z = D/4$ (same as before) plane.

EM field connected with network design



» Impedance parameters are calculated from currents given by the numeric solver.

» The solver has to provide S-parameters to prepare the system for network analysis.



Summary

- Electromagnetic modeling of WPT has been carried out
- Efficiencies and power density distributions have been calculated
- Results were transferred to network analyzer software