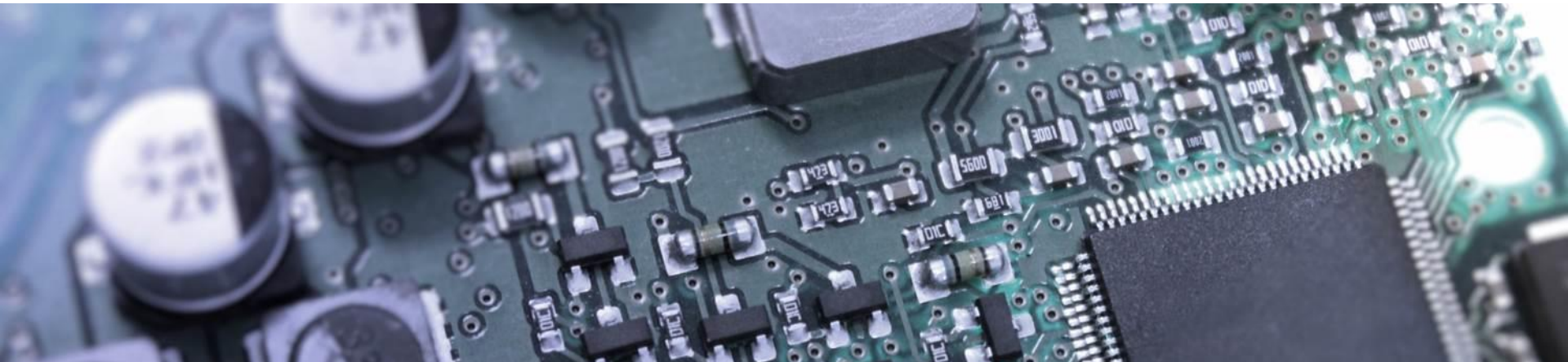




Extraction of 13.56 MHz NFC-Reader Antenna Parameters for Matching Circuit Design

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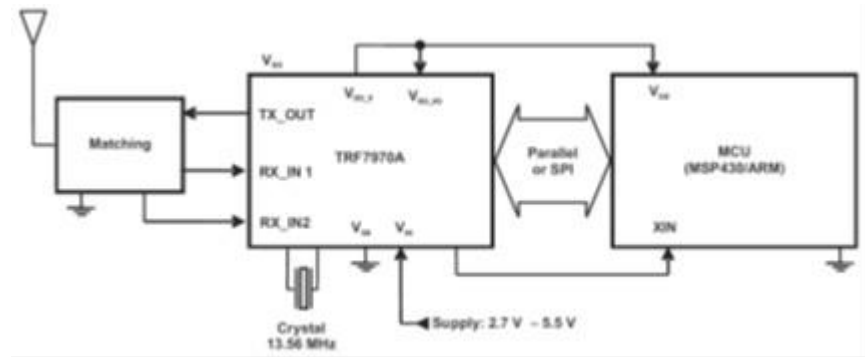
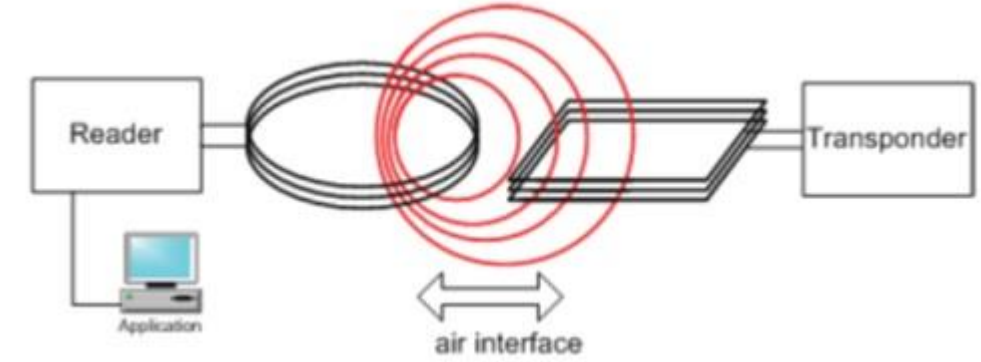
Outline of the Talk

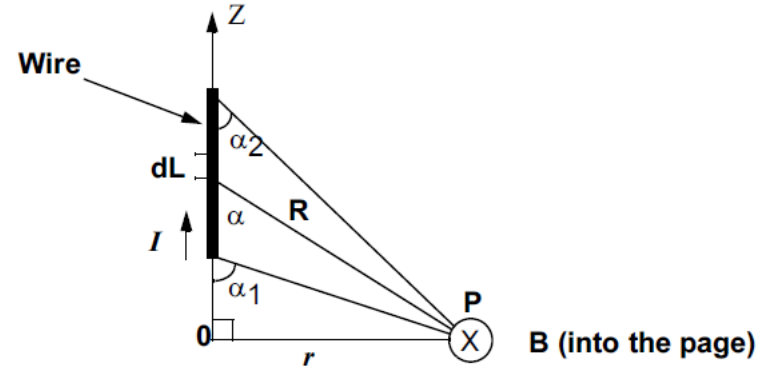
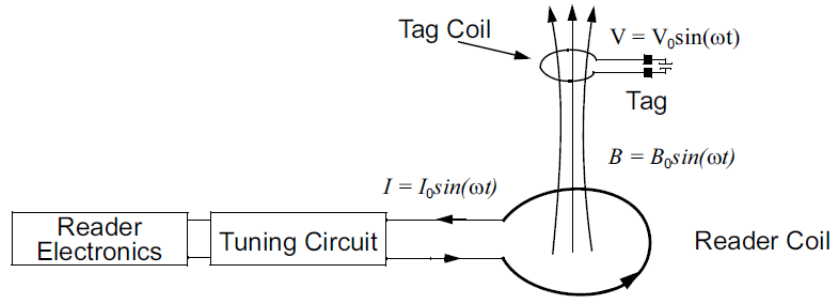


- **RFID- System and its Application**
- **Need for Matching (Tuning) Circuit**
- **Modeling of NFC-Reader-Antenna**
- **Simulation (Frequency Domain) of 3D-Antenna**
- **Parameter Extraction & VNA Measurements**
- **RF-Simulation for Matching Circuit Design**
- **Conclusions**

Application Areas:

- EAS
- RFID-based Ticketing
- Smart Card
- ePassport
- Proximity Coupling devices (door opener)





Matching Circuit will adjust the Q-factor and enhance the Power efficiency and Data Transfer Rate to/from the Antenna Coil

$$L_a = 4W_m / I_0^2, \quad R_a = \text{Re}(Z)$$

$$Q = (\omega L_a) / R_a$$

$$I_{rms} = I_0 / \sqrt{2}, \quad W_m = L_a I_{rms}^2 / 2$$

$$B = \mu_0 \mu_r I (\cos \alpha_2 - \cos \alpha_1) / 4\pi r$$

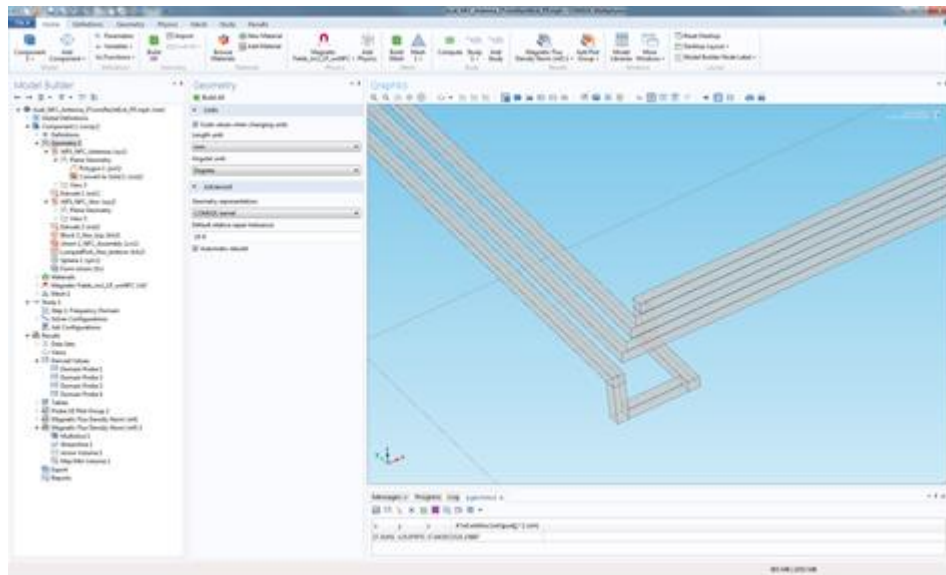
$$B = \mu_0 \mu_r I / 2\pi r, \text{ for } \alpha_2 = 0^\circ, \alpha_1 = 180^\circ$$

$$\psi_{mf} = \int B \cdot dA, \quad L_a = N \psi_{mf} / I$$

$$\delta = 1 / \sqrt{\pi f \mu \sigma}, \quad R_a = l / (\sigma A_{active})$$

Model Building Steps:

- WP1_NFC_Antenna (*wp1*)
 - Plane Geometry
 - Polygon 1 (*pol1*)
 - Convert to Solid 1 (*csol1*)
 - View 2
 - Extrude 1 (*ext1*)
 - WP1_NFC_Xtor (*wp2*)
 - Plane Geometry
 - Polygon 2 (*pol2*)
 - Polygon 3 (*pol3*)
 - Convert to Solid 2 (*csol2*)
 - View 3
 - Extrude 2 (*ext2*)
 - Block 3_Xtor_top (*blk3*)
 - Union 1_NFC_Assembly (*uni1*)
 - LumpedPort_Xtor_bottom (*blk2*)
 - Sphere 1 (*sph1*)
 - Form Union (*fin*)
- Materials
 - Cu_NFC_Antenna (*mat1*)
 - Air (*mat2*)
 - Copper_bound (*mat3*)
 - LumpedPort_Air_GF (*mat9*)
 - Air (2) (*mat11*)
- Mesh 1
 - Size
 - Free Triangular 1
 - Swept 1
 - Distribution 1
 - Free Tetrahedral 1
 - Size 1
 - Free Tetrahedral 2
 - Size 1



Extracted Parameter Values from Comsol Simulation:

$$L_{a_comsol} = 1.52 \mu H,$$

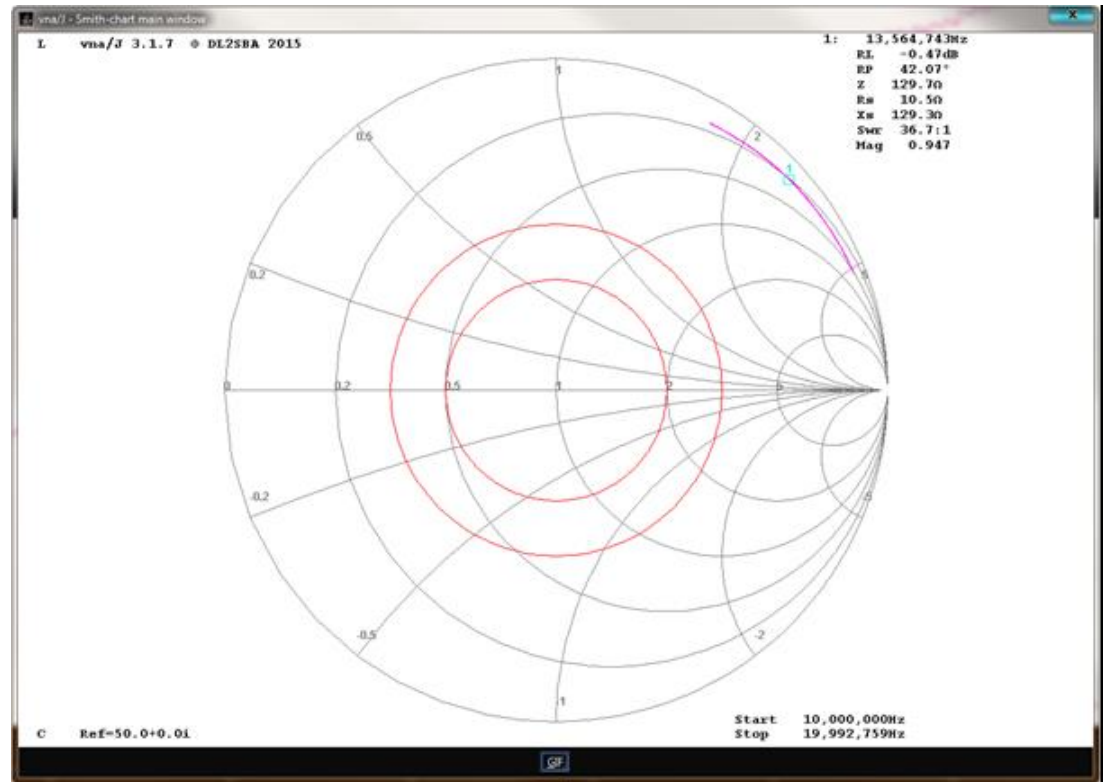
$$R_{a_comsol} = 1.6 \Omega$$

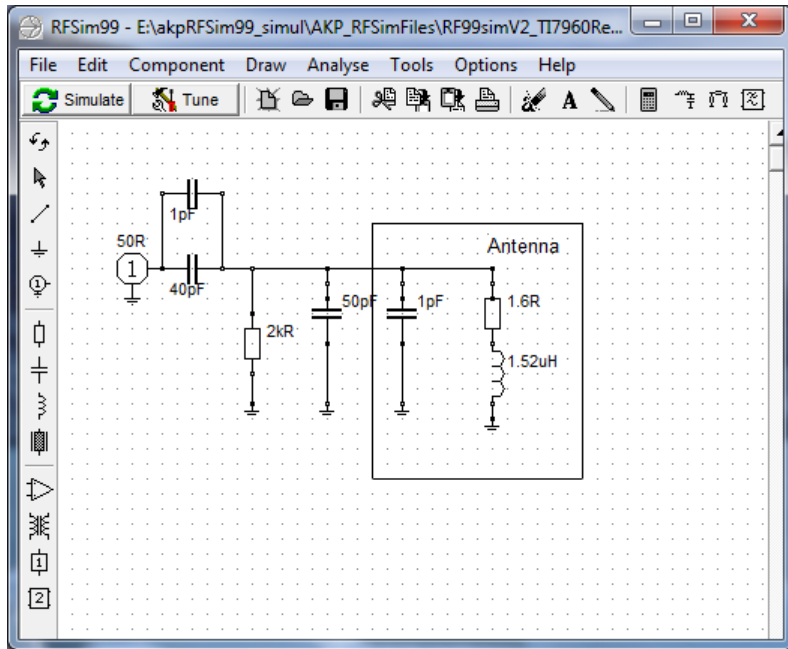
Antenna Parameter Values from VNA-measurements/Smith Chart:

$$X_s = 129.30 \Omega, \omega = 2\pi f = 8.52 \times 10^7$$

$$L_{a_vna} = X_s / \omega = 1.52 \mu H,$$

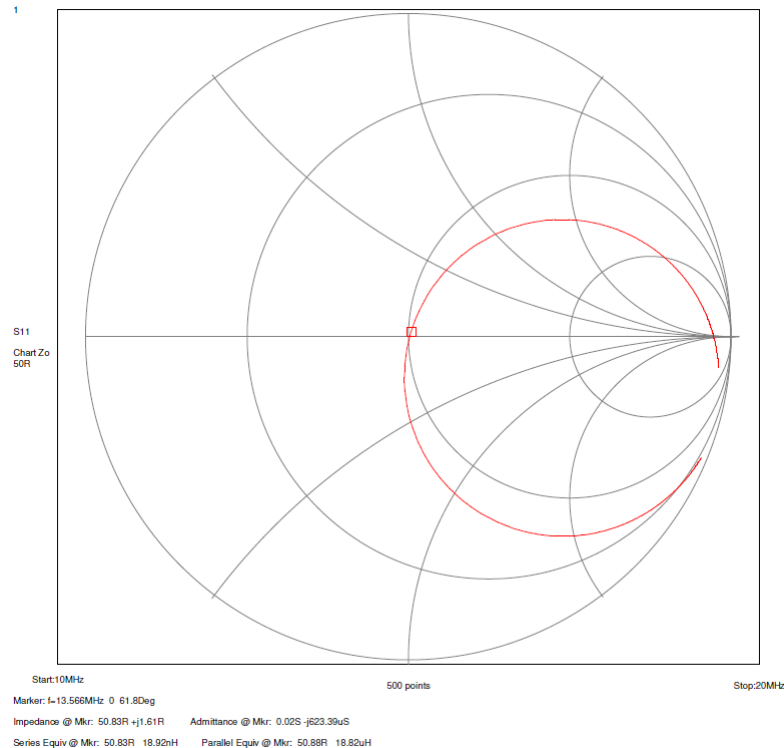
$$f = 13.56 MHz, R_{a_vna} = 10.3 \Omega$$





Damping Resistance 2k & Series and Parallel Capacitances (40pF & 50 pF) are selected from RF-Simulation

RFSim99 - E:\akpRFSim99_simu\AKP_RFSimFiles\RF99simV2_TT7960ReaderIC_L1pf52uH.cct





Conclusion:

- ✓ **3D-Model of NFC-Reader-Antenna was built and simulated using Comsol frequency domain tool.**
- ✓ **Antenna Parameters (L_a & R_a) were extracted at 13.56 MHz frequency and compared with VNA Measurements**
- ✓ **The L_a value matches reasonably good (max. 10 -15% error)**
- ✓ **Extracted parameters were used again for RF-simulation to design the suitable Matching Circuit**
- ✓ **Designed antenna performed very well with the proposed Matching Circuit components.**



Thank you very much for your attention!

