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

Prof. Dr.-Ing. habil. A. K. Palit[1]

[1]ZF-Lemfoerder Electronic GmbH, ZF-Friedrichshafen AG. Group, Espelkamp, Germany

Abstract

Introduction: RFID system uses a Transponder and the near field communication (NFC) antenna and a matching circuit (Figure-1) in which at least latter two must be optimally designed for a higher efficiency. Typically, RFID antennas are flat inductive coils with 2 to 4 turns and are printed directly on the PCB. The larger antenna size implies larger operating distance whereas, the number of turns and their layouts play a significant role in achieving the target inductance (1.0-3.0 micro-Henry). The geometry of the antenna is an important factor for achieving a target operating distance. Hence, based on the selected geometry/shape-and-size the NFC antenna is designed starting with two turns. The designed NFC-antenna's parameters must be measured with high accuracy with a vector network analyzer (VNA). The VNA delivers the S11 parameter/coil-inductance (La), series-resistance (Ra) and parallel-capacitance (Cpa) values of the antenna at 13.56 MHz. First two parameters are applied for the computation/RF-simulation of matching circuit [2, 3]. The optimal design of matching circuit is difficult without the information of NFC antenna parameters. The arbitrarily designed sub-optimal matching circuit will lead to a very poor performance of the best NFC-reader antenna. Therefore, accurate measurements/extraction of antenna-parameters are necessary for the optimal design of antenna- matching-circuit.

Use of COMSOL Multiphysics®: With the use of COMSOL Multiphysics® software and its frequency-domain modeling capabilities, one can extract the S11 parameters / estimate the aforementioned parameters of the NFC-antenna. If the geometry and dimensions of NFC antenna are known, the properly modeled NFC-antenna with the Magnetic Fields (mf) physics interface of COMSOL (Figure-2) can conveniently deliver those antenna-parameters with high accuracy. The COMSOL modeling performance can also be verified with the VNA measurements of S11-parameter.

Results: Figure-3 shows the simulation results obtained from a frequency-domain modeling of NFC-antenna at 13.56 MHz. The Magnetic Fields (mf) physics interface has been used for such modeling. Simulation result shows that the coil-inductance La = 1.52 micro-Henry and series-resistance Ra = 1.6 Ohm. The results obtained from COMSOL has been compared with VNA-measurements. Figure-4 shows the Smith chart plot of VNA with measured Xs = 129.30 Ohm, which gives La (VNA-measurement) = Xs/(2*pi*f) = 1.52 micro-Henry, where f = 13.56 MHz. This shows that the both inductance values are identical. Further simulations in most cases agree within 10-15% error limit.

Conclusion: An NFC-reader antenna was modeled using COMSOL capabilities for magnetic fields and frequency domain studies at 13.56 MHz. The coil-inductance and series-resistance of NFC-antenna obtained from the frequency domain model were compared with Vector-Network-Analyzer (VNA) measurements. It was observed that measured coil-inductance and series-resistance parameters of the antenna match very closely with the simulation results. Based on the extracted parameter values suitable matching circuit was designed and the performance of the latter was also tested. It has been observed that matching circuit designed with COMSOL performs very close to the matching circuit which was designed based on the VNA measurements. The simulation results were applied in the design-and-development of an NFC-reader-antenna and its matching circuit and used in the keyless automatic door opening system of the German cars.

Reference

[1] M. Gossar et. al., “Development of an Evaluation Reader for 13.56 MHz RFID Systems”, in the Proceedings of International Workshop on NFC, 2012.
[2] TI Application notes on TRF7970A
[3] NXP Application notes- AN11019, Rev. 1.1-26 January 2015
[4] NXP Design Guides/Notes: NFC Reader Antenna Design Guide, 2014

Figures used in the abstract

Figure 1: NFC- antenna needs the matching circuit to inteface with the TI-TRF7970A high performance transceiver chip. [2]

Figure 2: Partial (zoomed) view of a large NFC- antenna (3 turns) modeled using COMSOL.

Figure 3: Frequency domain modeling of NFC Antenna (COMSOL simulation results).

Figure 4: Vector Network Analyzer (VNA) measurement of the NFC-Antenna.