# AN5308
# Application note

## Near field loop antenna for the ST25RU3993-EVAL board

## Introduction

This document describes a near field antenna developed for short range RAIN® RFID UHF applications.

This antenna, integrated on the ST25RU3993-EVAL board, is for evaluation purposes only. It is designed to read tags at a short distance (range limited to approximately 0.5 m). Increasing the output power of the ST25RU3993 device will not lead to longer read ranges, achievable with far-field antennas.

The design of the antenna is a circular microstrip transmission line with a 50 Ω termination.

# Contents

# List of figures

# 1 List of acronyms

| | |
|---|---|
| UHF | Ultra high frequency |
| RFID | Radio frequency identification |
| NF | Near field |
| EM | Electromagnetic |
| S11 | Input reflection coefficient |

# 2 References

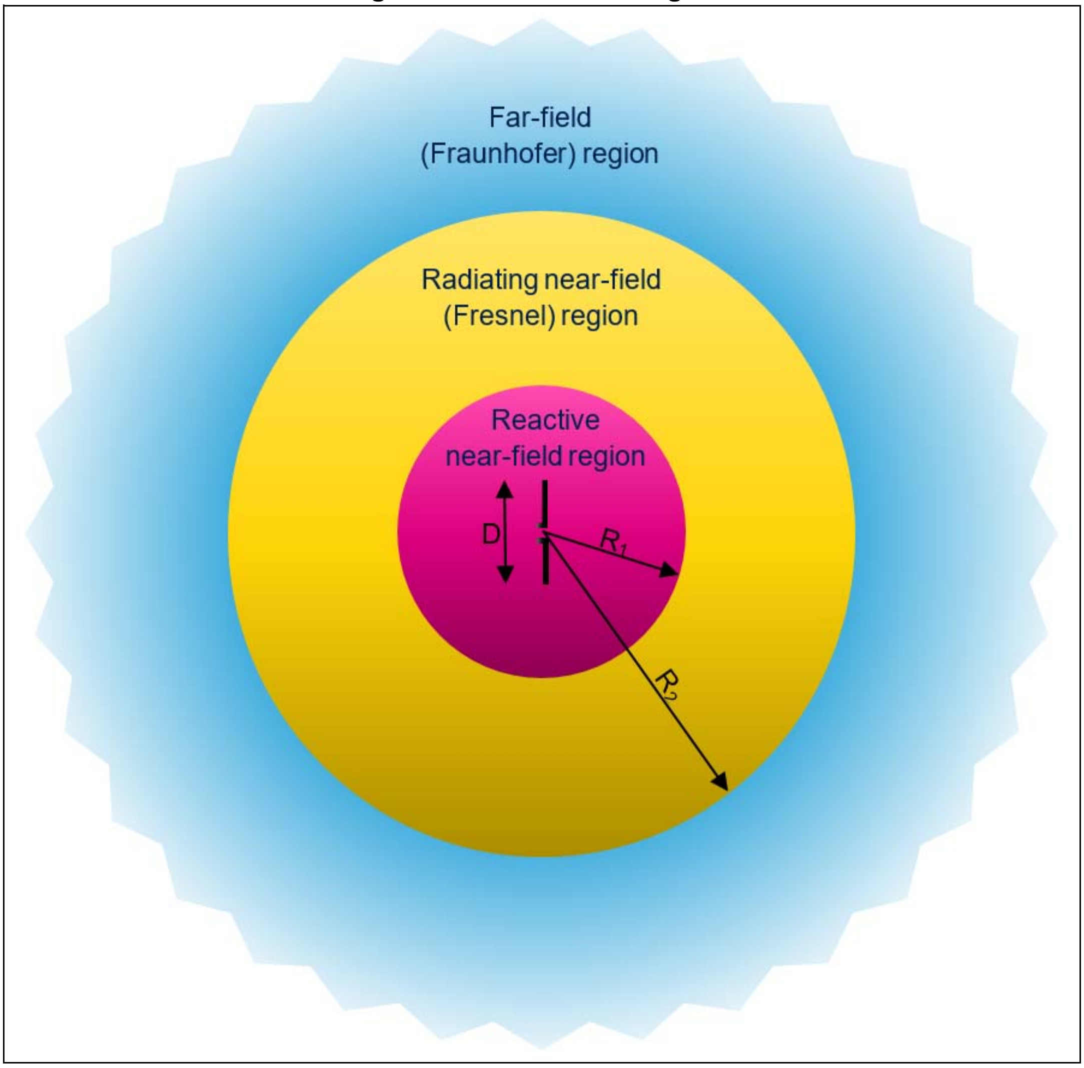

| | | | |
|---|---|---|---|
| [1] | C A Balanis | Antenna Theory | Wiley and sons, 2016 |
| [2] | G Manzi | Use of Transmission Lines as Near Field Antenna in UHF RFID | IEEE 2012 International Conference on RFID Technologies and Applications |
| [3] | | AppCAD for Windows® | Agilent Technologies, 2002 |

# 3 Design

According to [1], the space surrounding an antenna can be divided into three regions, shown in Figure 1:

1. reactive near field (from r = 0 to r = $R_1 = 0.62\ (D^3 / \lambda)^{1/2}$
2. radiating near field (from $R_1$ to $R_2 = 2\ D^2 / \lambda$)
3. far field (distances larger than $R_2$)

**Figure 1. Antenna field regions**

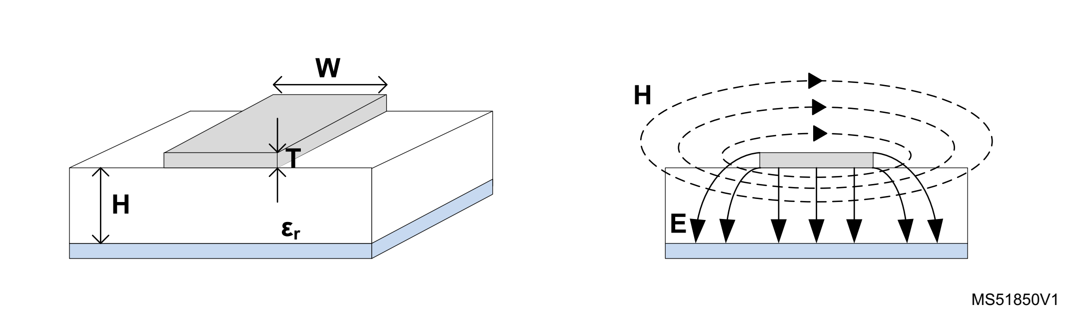



Ideally a UHF RFID tag must work within the Fresnel region of the reader antenna, with a homogeneous EM field distribution.

According to [2], this can be achieved by a circular microstrip transmission line matched to the reader RF output impedance of 50 Ω. This is done with an SMD resistor.

The typical structure of such a transmission line is shown in the left side of *Figure 2*, while in the right side the magnetic and electric field distribution in the cross section of the microstrip line are schematized with, respectively, dashed and solid lines.

**Figure 2. Microstrip line structure and field lines**




The magnetic field surrounds the conductor in closed lines and the electric field lines connect (more or less directly) the conductor to the ground plane. This leads to low far field radiation.

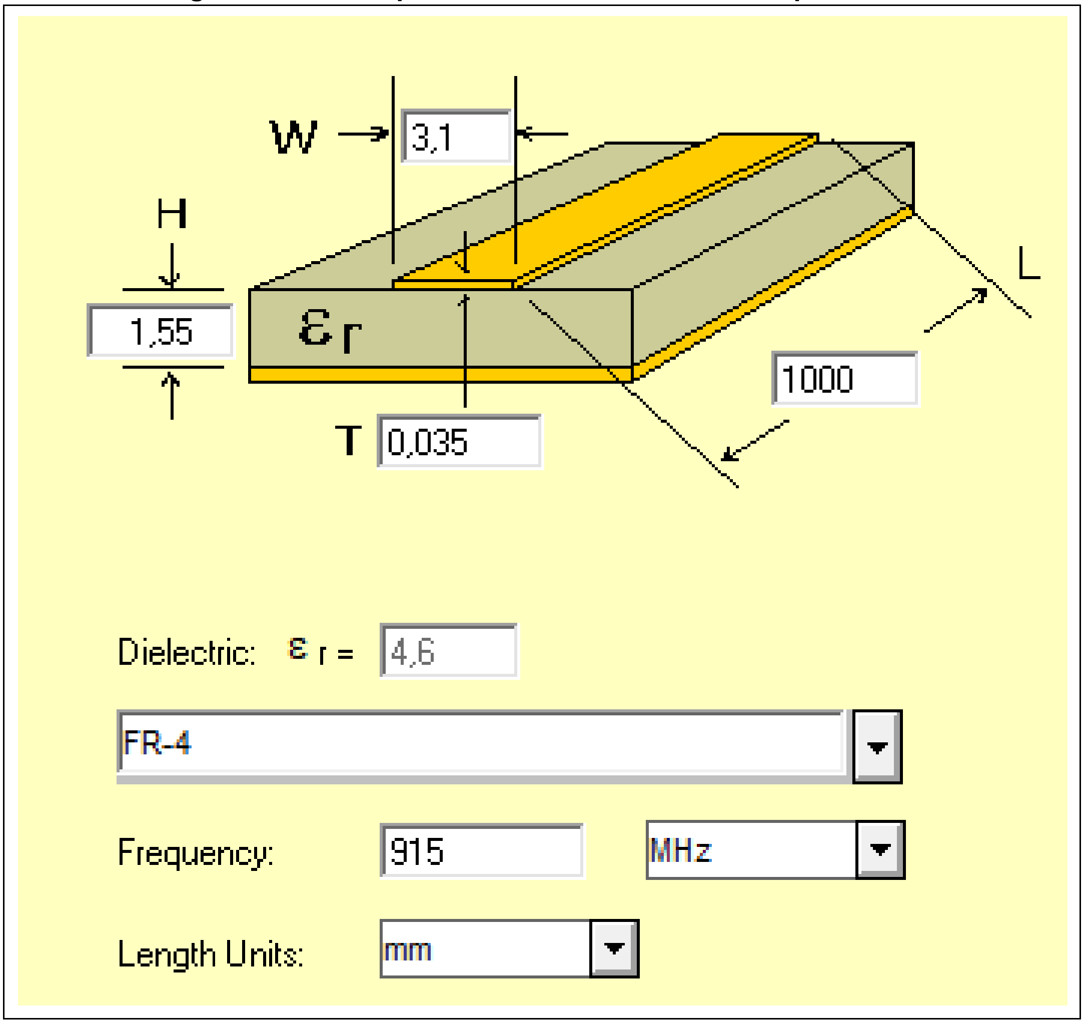
With reference to *Figure 2*, the microstrip design parameters are:

- W: conductor width
- T: conductor thickness
- H: substrate height
- $\varepsilon_r$: substrate dielectric constant (~4.6 for the FR-4 material).

The operation frequency is an additional key parameter for the antenna performance.

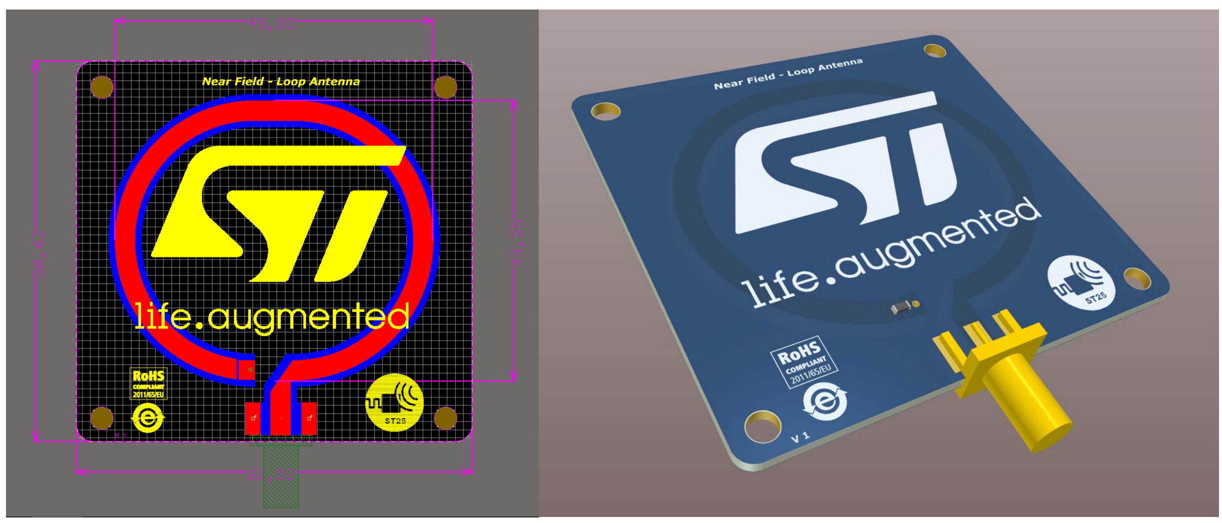
Figure 3 (from [3]) shows the design of the microstrip line used in the NF loop antenna. The ground plane is formed by a trace on the bottom layer of the PCB with 5.1 mm width, which follows the transmission line on the top.

**Figure 3. Microstrip line dimensions of the NF-loop antenna**



The actual design of the NF loop antenna is shown in *Figure 4*.

**Figure 4. Antenna on the ST25RU3993 EVAL board**



# 4 Results

EM solver simulations and measurements have been carried out to verify the antenna design.

## 4.1 Simulation

The EM solver model is shown in *Figure 5*, where the blue point indicates a 50 Ω resistor and the red rectangle the wave guide port.

**Figure 5. EM solver model for the NF loop antenna**

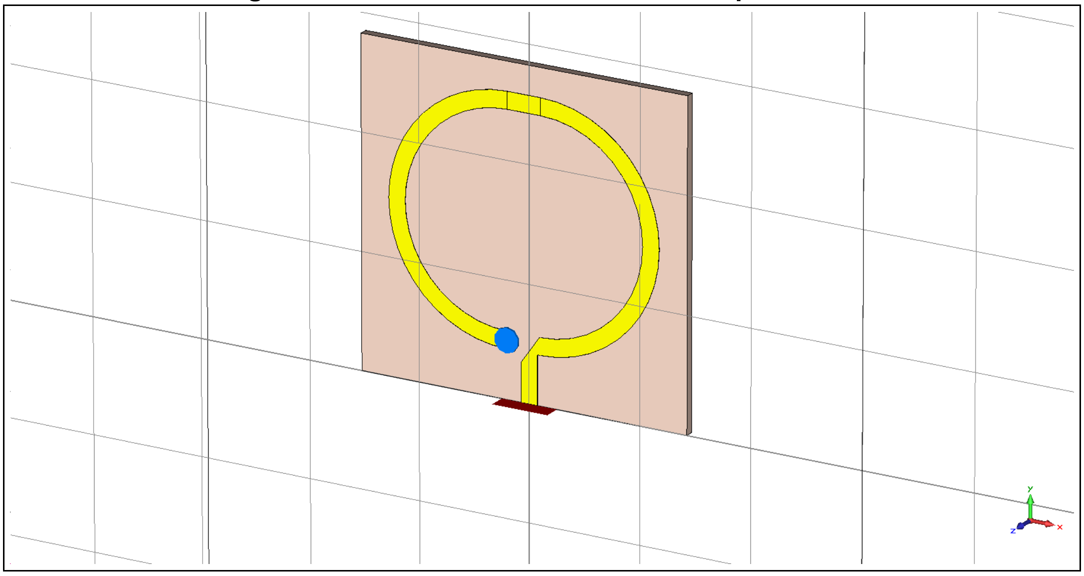
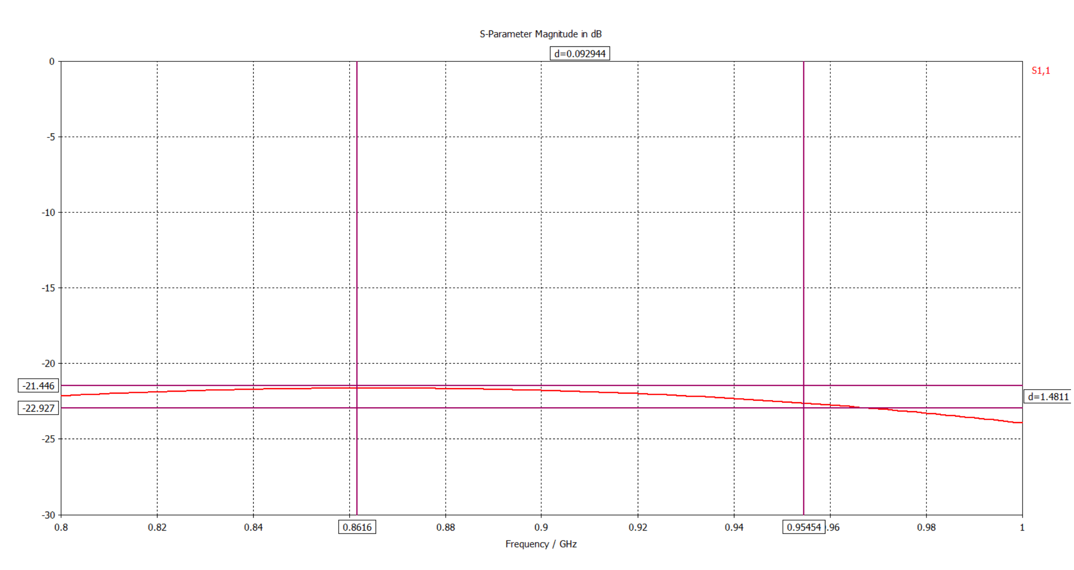


*Figure 6* shows the S11 results of the simulation. The input reflection coefficient is below -21 dB across the whole UHF RFID frequency range. This leads to an excellent low mismatch loss of ~0.03 dB.

**Figure 6. S11 according to the EM simulation**



The far field radiation behavior of this antenna has been simulated as well. The antenna gain at both 860 MHz (*Figure 7*) and at 915 MHz (*Figure 8*) is lower than -25 dB, indicating almost no far field radiation properties.

**Figure 7. Antenna gain at 860 MHz**

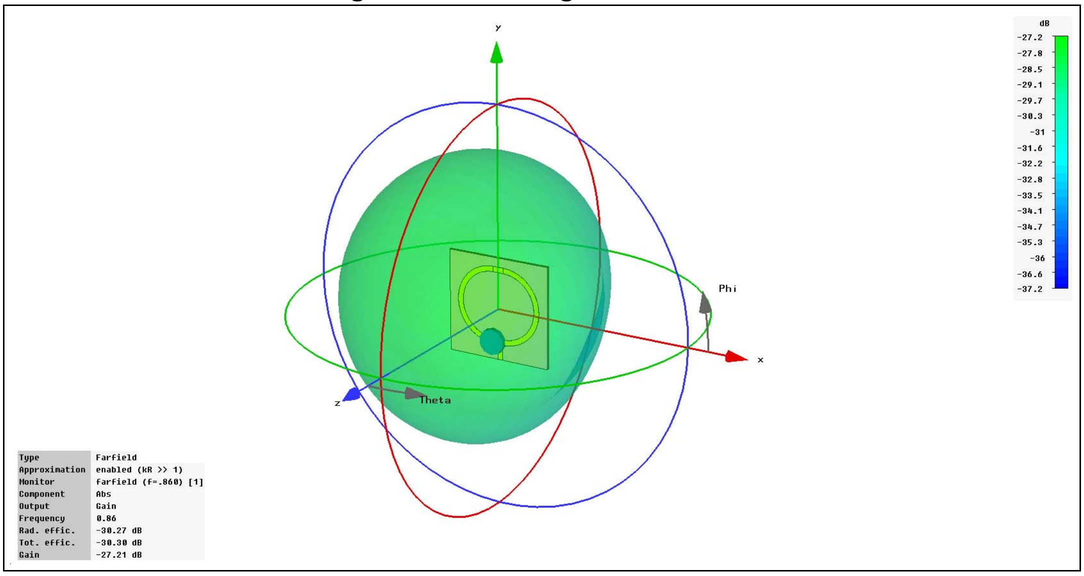
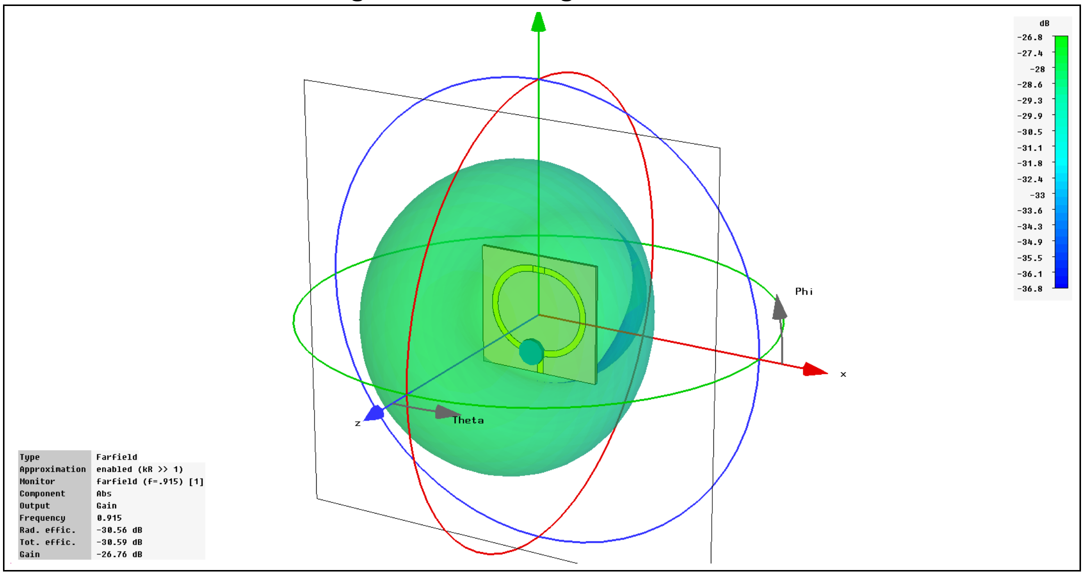



**Figure 8. Antenna gain at 915 MHz**



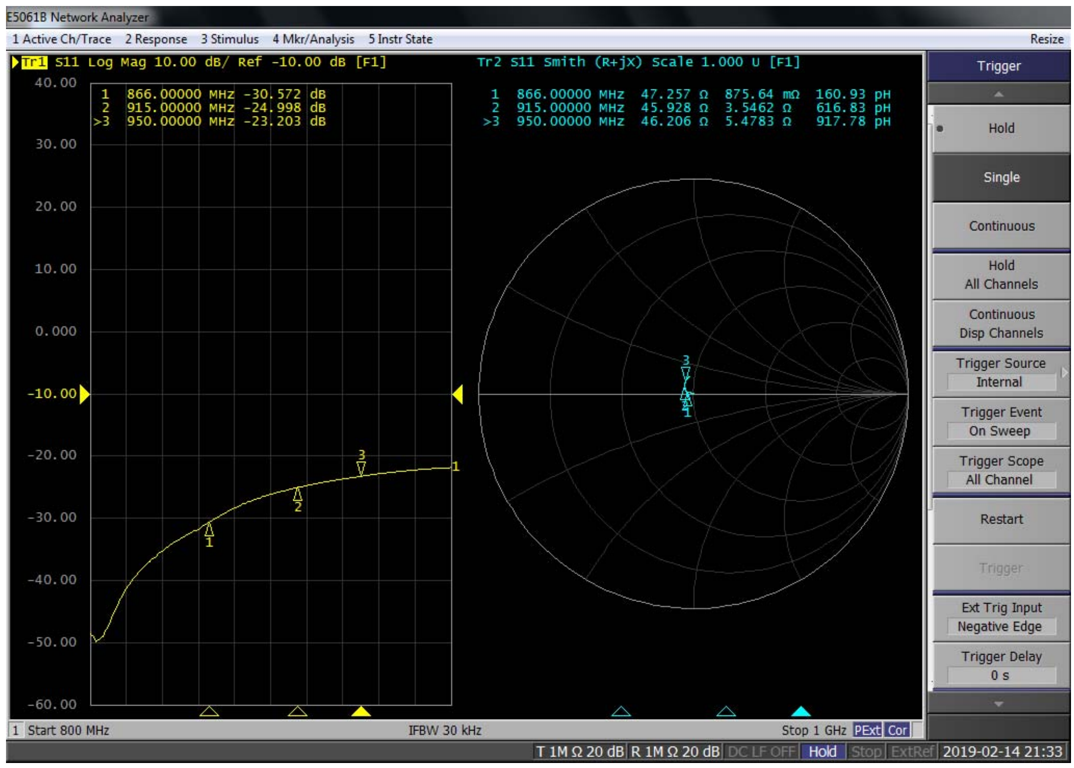
## 4.2 Measurements

To confirm the EM simulation results, the key antenna parameters have been measured using a vector network analyzer. These measurements also prove the performance of the NF loop antenna in the application.

S11 has been measured, and the results have been compared to the data from the EM simulation. As can be seen from *Figure 9*, the measured value is even lower than the simulated one. This proves that the NF loop antenna impedance is well matched to 50 Ω.

The difference between the measured value and the simulation can be explained by differences in the dielectric constant of the modeled FR-4 substrate, and on the assembled termination resistor, whose actual value is 51 Ω (plus its tolerance).

**Figure 9. S11 measurement with the network analyzer**



# 5 Conclusion

This document describes the basic antenna design for the ST25RU3993-EVAL board.

The use of a circular microstrip transmission line with a 50 Ω termination has resulted in a low reflection coefficient. Both the simulations results and the experimental data prove the viability of this solution for near field RAIN® UHF RFID applications.

# 6 Revision history

**Table 1. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 14-Mar-2019 | 1 | Initial release. |