AN 1685

Baggage Tag Reference Antenna Design for the UCODE G2XM / G2XL IC

Rev. 1.0 — 26 January 2009   **Application note**

Document information

Info	Content
Keywords	UCODE EPC G2, G2XM, G2XL, Reference Design, Antenna Design, Baggage tag, Aluminum
Abstract	This application note describes a baggage tag design for the UCODE G2XM / G2XL. This design represents a reference design to demonstrate performance of the NXP UCODE G2XM / G2XL.

Revision history

Rev	Date	Description
1.0	20090126	First initial release; Authors: Benno Flecker

1. Introduction

The International Air Transport Association (IATA) has introduced a global standard for RFID baggage tags that paves the way for widespread use of RFID for baggage management by airports and airlines.

This introduction of the IATA standard RP1740c sends a clear signal that RFID helps to achieve a greater performance and capacity with the same baggage infrastructure.

The new standard uses UHF frequency, which is licensed by different countries at different bands and powers. The air interface protocol employed is ISO-18000-6-C, which is an open standard that defines the way in which the reader talks to the tag and the way the tag responds. Two other protocols, ISO-15691 and ISO-15692, will be used to delineate data compression for storage and identify commands that are available to interact with the tag.

2. Technical requirements on a Baggage Tag Design

- Region: world wide 840 – 960 MHz;
- Read Range > 6 m
- IC: G2X (Z_{IC} = 22 – j 195 Ohm @ 915 MHz @ P_{IC} = $P_{IC\ min}$);
- Packaging type: direct chip attach;
- Performance in presence of additional dielectrics and still operate world wide.
- Fit to IATA Resolution 740 baggage tag

3. Baggage Tag Reference Antenna Design

3.1 Geometry

- Dimensions of the design: 80 mm x 35 mm;
- Antenna material: aluminum; thickness 15 µm;
- Substrate material: PET; thickness 50 µm;
- Antenna should be matched to following assembled IC impedance:

  ($Z_{ass. IC}$ = 22 – j 195 Ohm @ 915 MHz @ P_{IC} = P$_{IC\ min}$);

  C_{ass} = 0,3 pF;
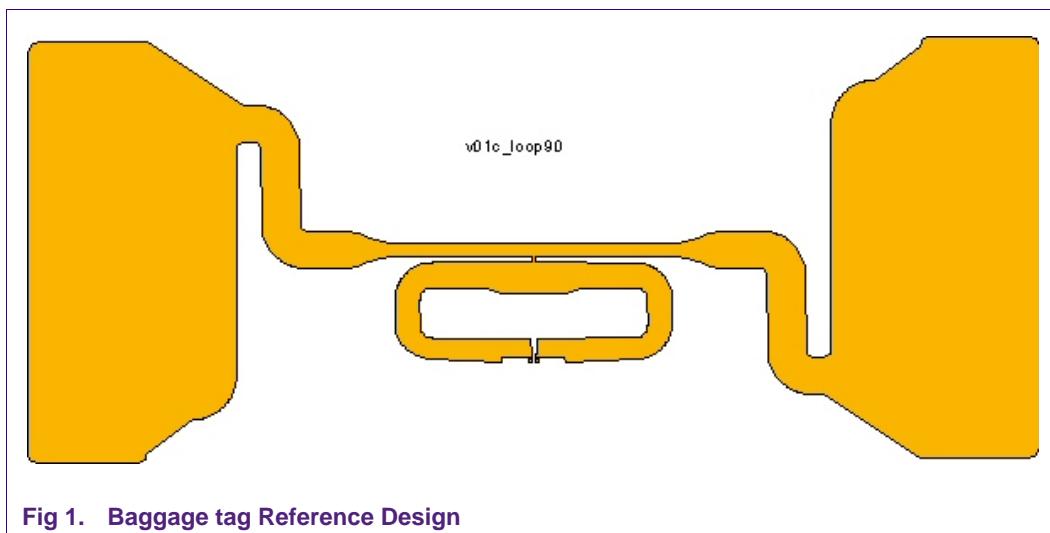
Fig 1.   Baggage tag Reference Design

3.2 Design description

To meet all of the above listed requirements a series of special design concepts have been worked out.

The requirement of long read range calls for a utilization of resonance dipole.

To make the conjugate-complex matching between the antenna and the imaginary (capacitive) part of the transponder IC, a small, a small inductive loop is utilized.

To ensure the required increased bandwidth of the label the classical conjugate-complex matching technique is set aside. The antenna is tuned in such a manner that a good compromise between a required label performance (Read Range) and a required bandwidth (more than 100 MHz) is made.

In the present design a dipole structure is connected with a loop based matching network.

4. CST Simulation Results

The following simulations are solved using CST, a commercial 3-D finite difference time domain (FDTD) solver for electromagnetic structures used for antenna design and the design of complex RF electronic circuit elements.

4.1 Antenna Impedance

One of the key characteristics of the label antenna is its complex input impedance as a function of frequency. The curves of real part and imaginary part of the optimized design are shown in Fig 2 and Fig 3.


Fig 2. Real part

Fig 3.   Imaginary part
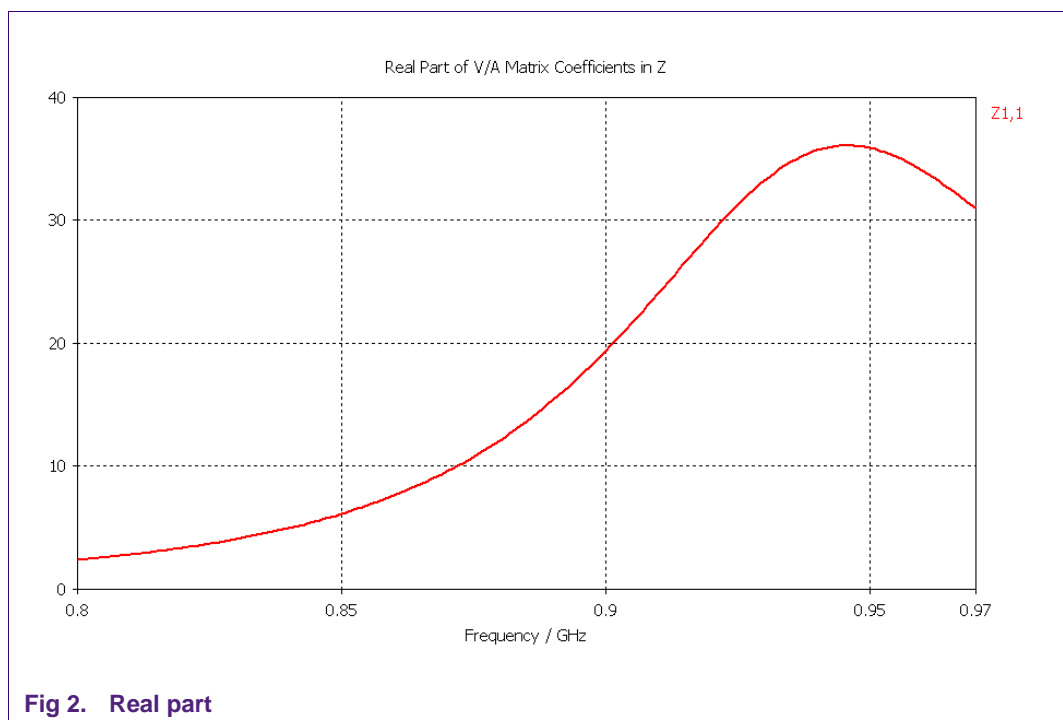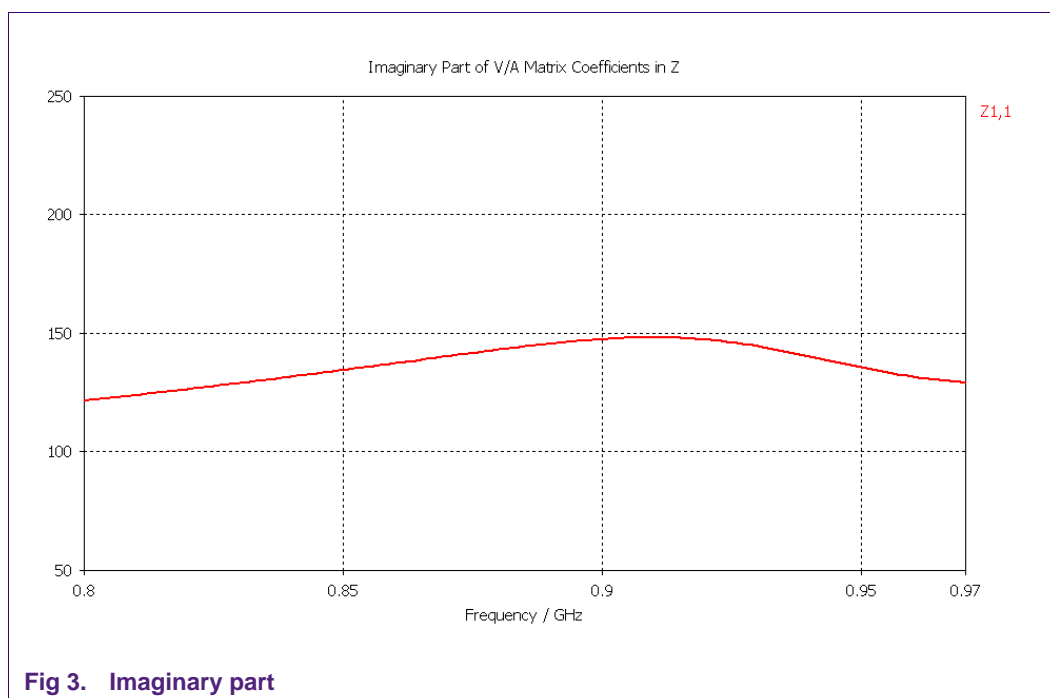
4.2 Return Loss

The antenna impedance on one side and the IC impedance on the other let calculate the return loss, Γ, which show a degree of matching between them (**Equation 1**).

$$\Gamma = \frac{Z_A - Z_{IC}{}^*}{Z_A + Z_{IC}}$$

(1)

The corresponded curve is shown in Fig 4. The curve is based on the assumption that the IC impedance remains constant for all frequencies and corresponds to those, measured at 915MHz by $P_{IC} = P_{min\,IC}$
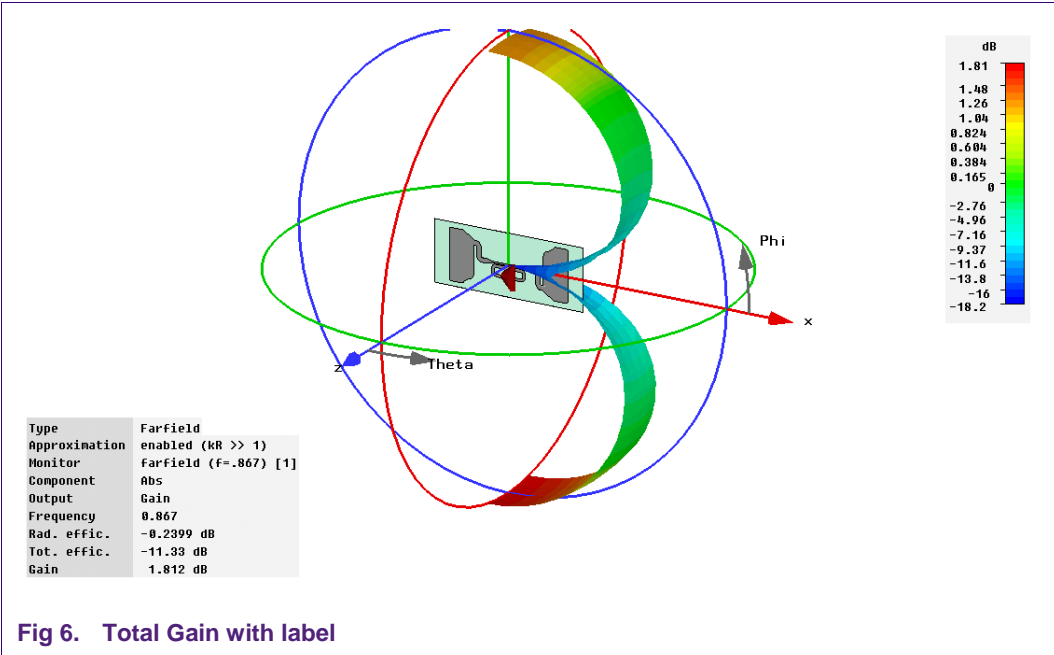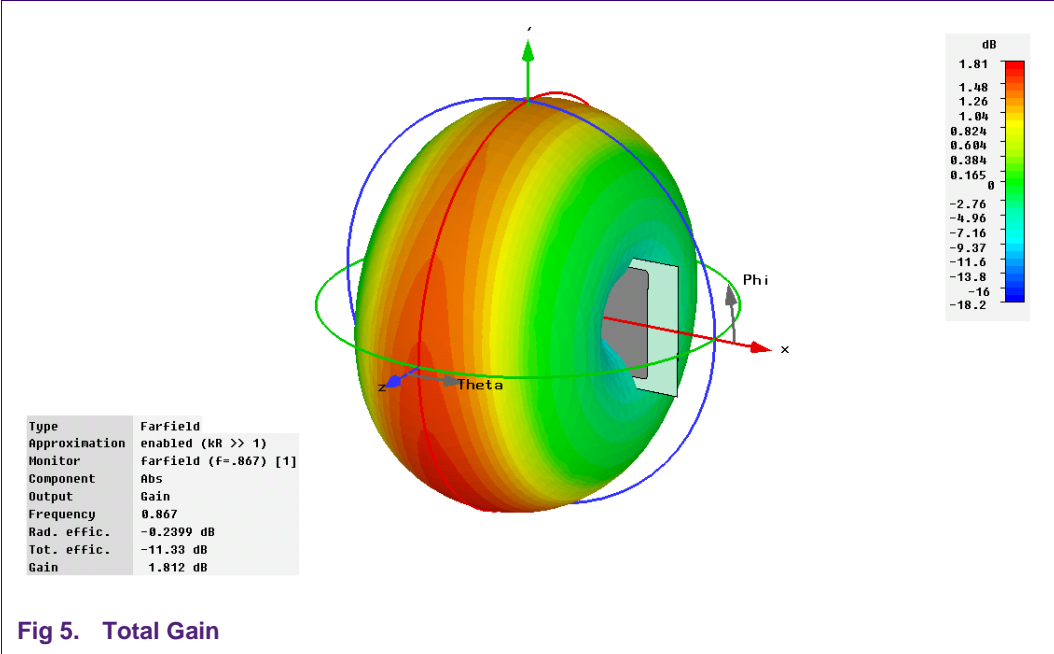
Fig 4. Resonance frequency
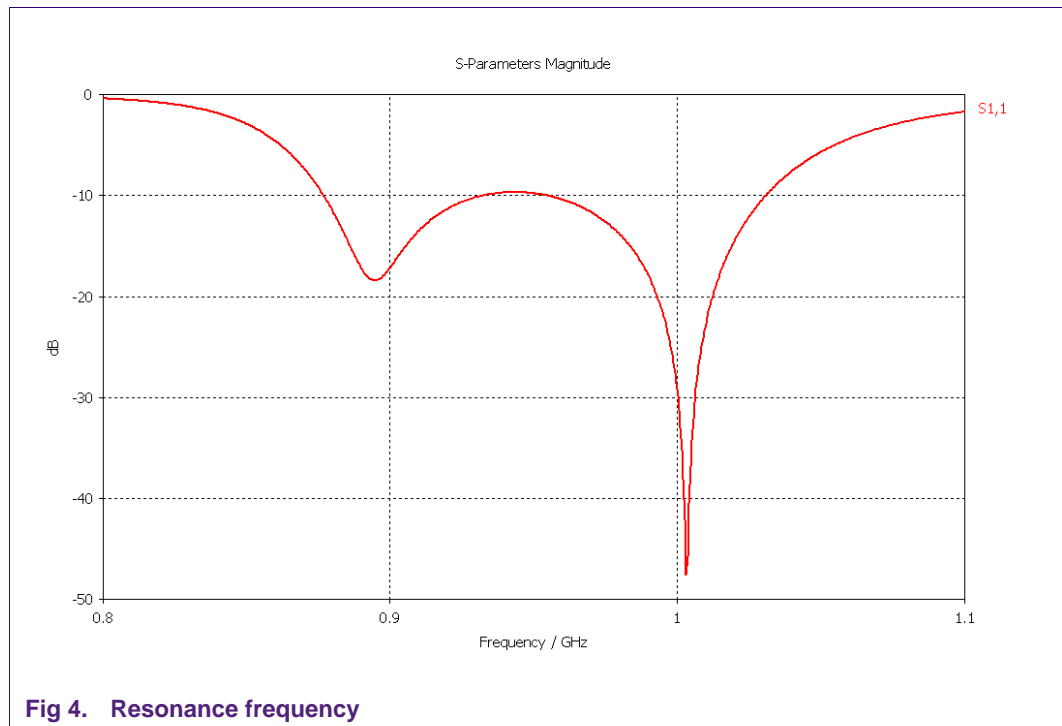
The matched frequency area covers the whole UHF RFID frequency band (860-960 MHz).
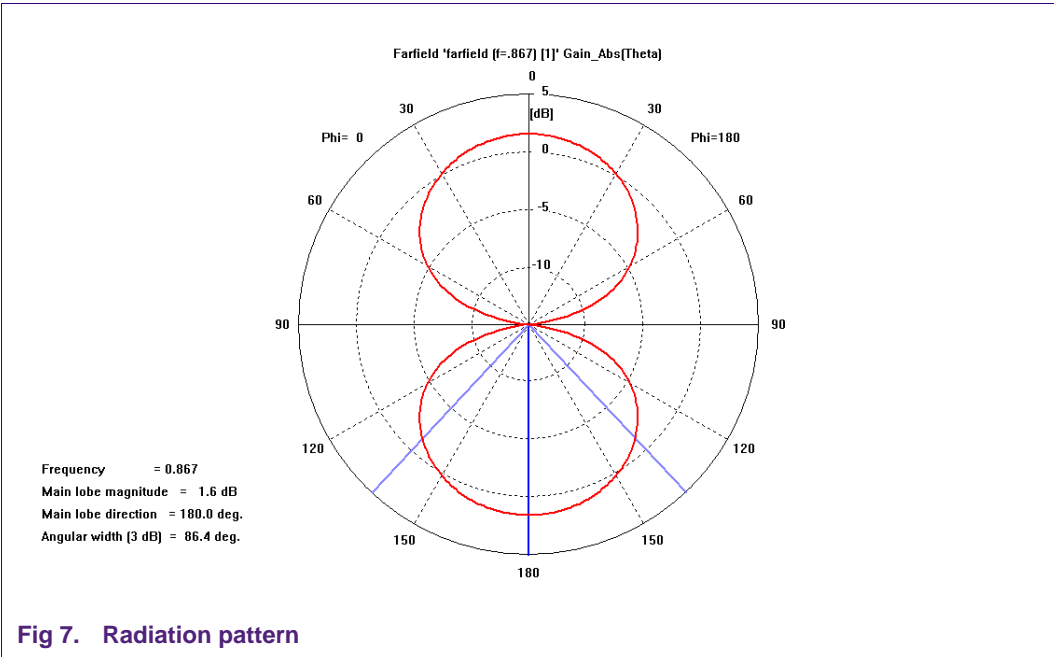
4.3 Antenna Gain

The fundamental characteristics of an antenna are its gain and beam width. According to the reciprocity theorem, the transmitting and receiving pattern of an antenna is identical at a given wavelength. The gain is a measure of how much of the input power is concentrated in a particular direction. It is expressed with respect to an isotropic antenna, which radiates equally in all directions.

In the following sections the simulated 3-D antenna radiation pattern for 867 MHz are shown. The dipole structure of the label antenna is positioned in the x-y-plane with arms pointing in y-direction.

The label radiation properties are shown in Fig 5 - Fig 7.

Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=.867) [1]
Component	Abs
Output	Gain
Frequency	0.867
Rad. effic.	-0.2399 dB
Tot. effic.	-11.33 dB
Gain	1.812 dB

Fig 5.   Total Gain

Type	Farfield
Approximation	enabled (kR >> 1)
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Component	Abs
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Frequency	0.867
Rad. effic.	-0.2399 dB
Tot. effic.	-11.33 dB
Gain	1.812 dB

Fig 6.   Total Gain with label

Fig 7. Radiation pattern

5. Assembly process

5.1 Equipment

- Thermode Test Station TTS 300 from Mühlbauer
- Low force thermode

5.2 Recommended assembly parameters

- Temperature

  - Upper thermode: 185°C
  - Lower thermode: 180°C

- Bonding time: 10 sec.

- Bonding pressure: 1,9 N

6. Measurement Method

The measurements were conducted with label prototypes. Therefore possible performance tolerances have to be taken into account.

6.1 P_{min} measurement

The minimum power measurements are carried out in an anechoic chamber, according to the measurement setup described in the EPC global document "Tag Performance Parameters and Test Methods Version 1.1.1".

The information gained from this measurement method is the minimal required power level at the label for powering the IC. This minimal power (P_{min}) is measured for a defined frequency range from 840 MHz to 990 MHz. **Fig 9** shows the P_{min} measurement results of all assembled antennas.
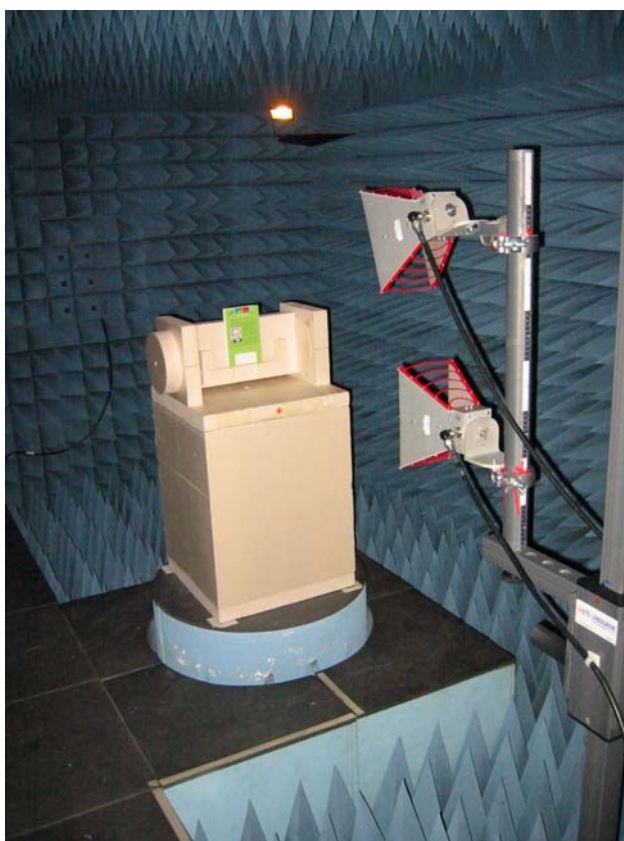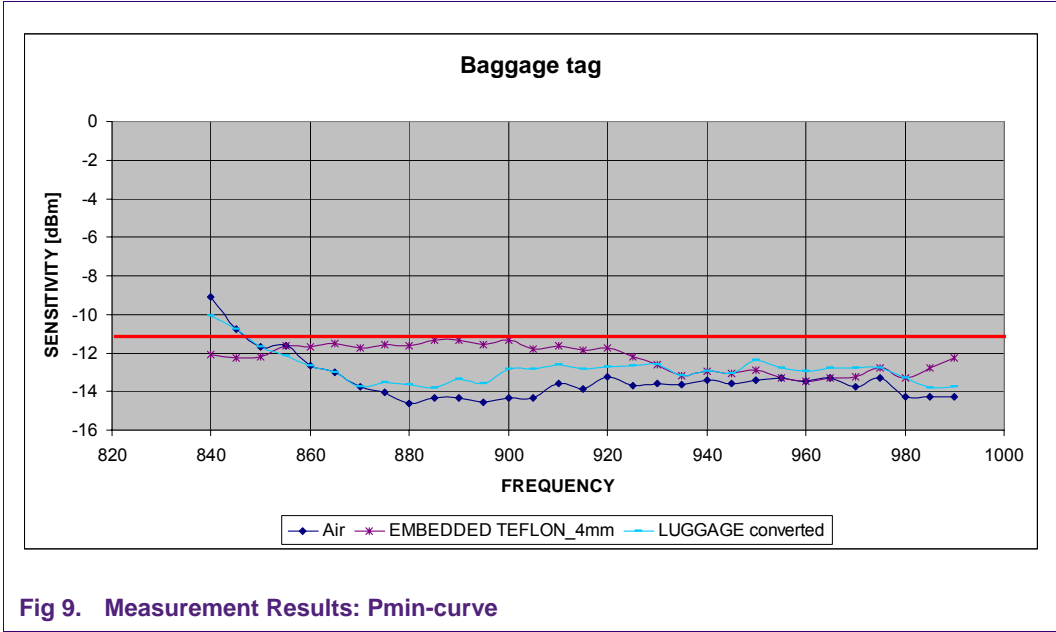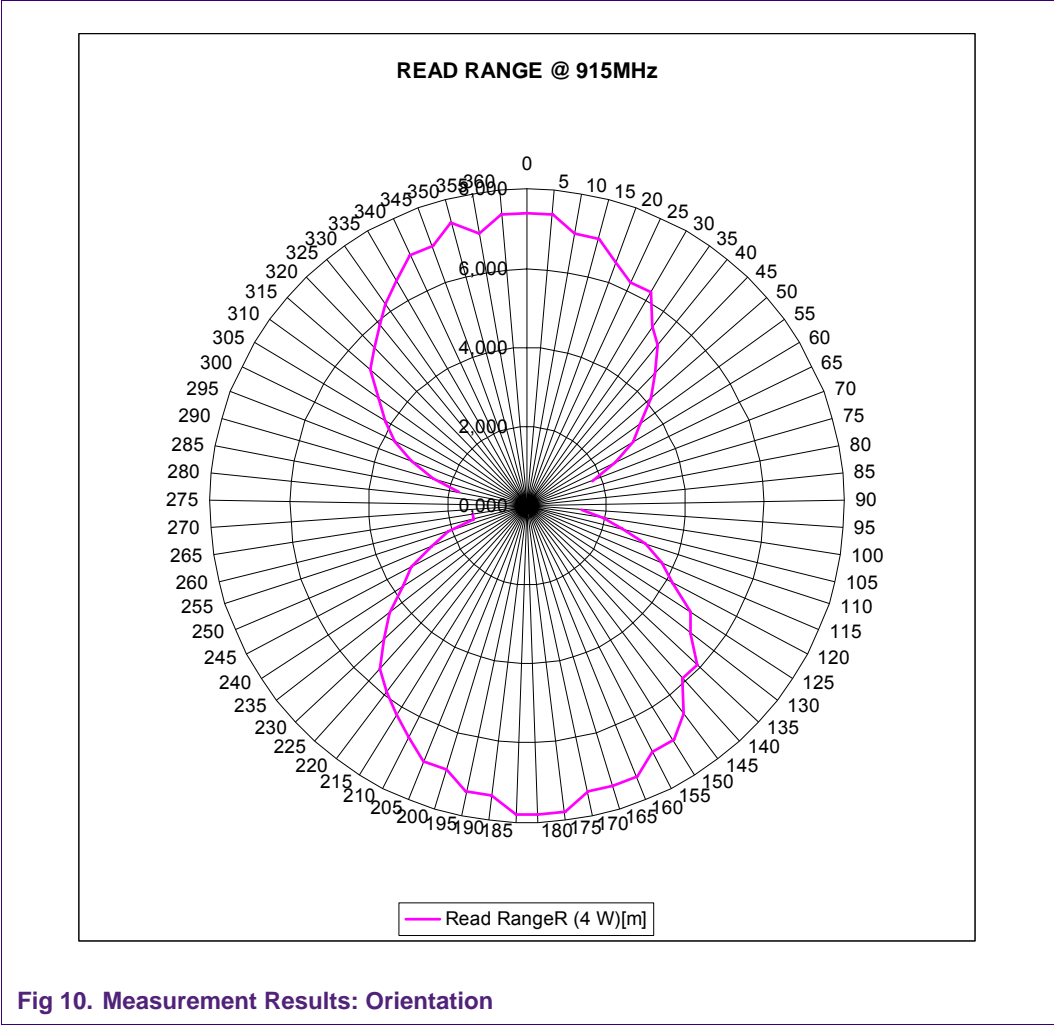

Fig 8. Measurement setup

7. Measurement Results

7.1 P_{min} measurements results

Baggage tag

Fig 9. Measurement Results: Pmin-curve

7.2 Orientation measurements results

Fig 10. Measurement Results: Orientation

8. Conclusions

Airline baggage applications have specific requirements for UHF label antennas in order to reach reliable read rates and read ranges.

Intense physical studies have translated the required features like broad bandwidth into design concepts. These have been optimized with the 3D electromagnetic simulation tool CST.

Measurements of prototypes have confirmed the simulated results.

This application note described a reference label antenna design optimized for baggage applications.

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