AN11215

UCODE G2i PCB Antenna Reference Designs

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Application note
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Document information

Info	Content
Keywords	UCODE EPC Gen2, G2i, Antenna Reference Design, PCB Antenna Design
Abstract	This application note describes three antenna reference designs for the UCODE G2i IC for implementation on a Printed Circuit Board (PCB).

Revision history

Rev	Date	Description
1.1	20130605	Update small antenna design
1.0	20120910	First initial release

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1. Introduction

The UCODE tag is compliant with the GS1 EPC™, Class-1 Generation-2 standard [1] and can be read by various RFID readers like fixed-mount-, gate-, tunnel- or handheld-readers. The read distance is dependent (amongst other things) on the type of the reader antenna and the design of the antenna on the PCB. Related to the design on the PCB the read distance for a large part depends on the size of the UHF antenna on the PCB. this document mainly describes the influence of the size of the antenna.

Real life applications may require different reading distance. The UCODE tag works with an antenna that is integrated on the PCB in the device. This application note describes three antenna reference designs with a large, medium and small antenna for a large, medium and small read distance. Conceptually the antennas utilize the ground planes of the PCB. The read performance is dependent upon the amount of copper in the ground plane. As a rule of thumb, more copper surface means more reading distance.

This application note provides measurement results with maximum and minimum amount of copper surfaces in the ground plane. For real life application the performance can be expected to be in the middle of the measured results. All measurements are done with "broadband" antenna designs (not specifically tuned for a certain geographic area).

The measurements in this application notes are optimized for optimal antenna orientations of both the reader and the tag antennas. All measurements are done in "free air", so without any loss due to some kind of shielding for example by the housing or other materials surrounding the PCB.

The measurement setup for the measurements in this application note is described in section 2. Section 3 described general design rules. Sections 4, 5 and 6 describe the antenna reference designs for the large, medium and small antennas respectively.

2. Measurement setup

This section describes the setup for the measurements in this application note.

2.1 Measurement setup

The minimum power measurements are carried out in a shielded 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 840MHz to 960MHz.

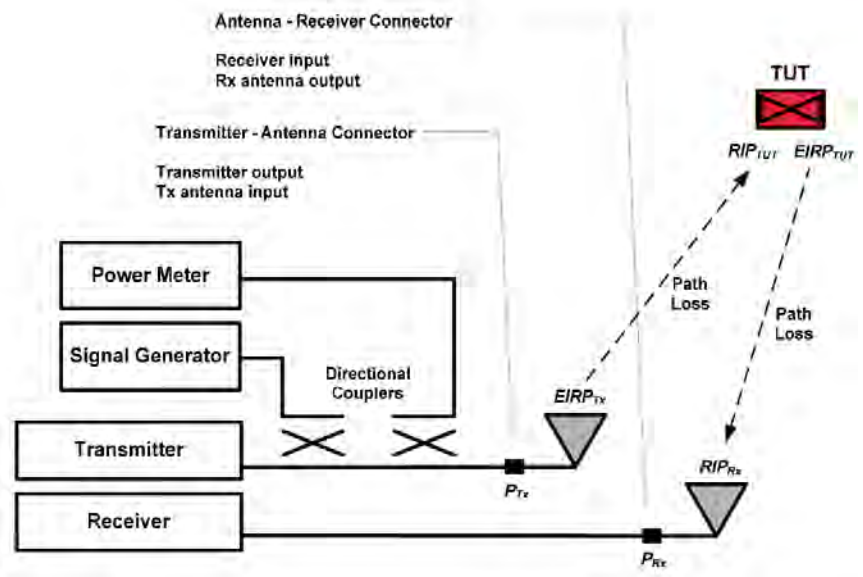

Fig 1. Measurement Setup

2.2 Measurement in anechoic chamber

The read performance also depends on various environmental parameters. To eliminate all environmental factors as much as possible all measurements have taken place in an anechoic chamber.

Fig 2. Measurement Setup: Anechoic chamber

Note: The red arrow shows Tag position, PCB position horizontal (Fig 2) and vertical

Details of the measurement setup:

- **Reader antennas:** two bi-static horns with step attenuator
- **Reader antenna power:** 4W EIRP
- **Tag orientation:** PCB Horizontal (main beam of slotted antenna)
- **Distance between reader and PCB antenna:** 1 meter

3. General design rules

This section describes some general design rules for the antenna designs.

3.1 Antenna slot characteristics

The functional behavior of the PCB antenna is for a large part defined by the design of the antenna slot. The size of the slot defines the reading distance performance and the perimeter of the slot defines the antenna tuning.

3.2 Adaption for European and US bands

The operating frequency of an RFID system differs in Europe versus the US. In Europe the RFID systems must operate within the 865.6MHz - 867.6MHz band whereas in the US the RFID systems must operate within the 902MHz – 928MHz band.

For optimal operation the tag antennas need to be tuned to the correct frequency by varying the antenna slot perimeter values.

4. Large antenna reference design

This section describes the design of an antenna with the largest reading distance.

4.1 Antenna Geometry

The antenna is an integral part of the PCB. The brown part in Fig 3 represents the ground plane (in this case the antenna fills the entire PCB).

The surface that is marked with the dotted line marks the minimum size of the ground plane.

In a real life application most of the ground plane surface will be occupied by electronic components and therefore the read/write performance may be less than the performance of this reference design antenna.

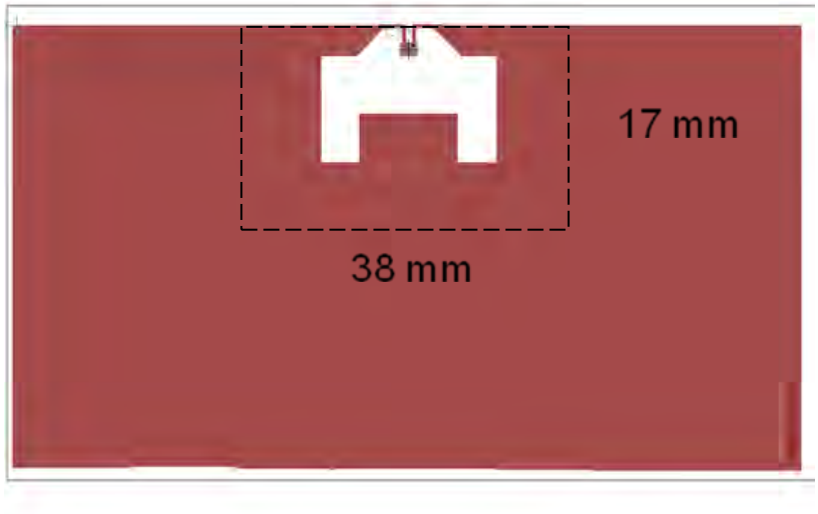

Fig 3. Large Antenna Reference Design

Details of the antenna design:

- Dimensions of the board: 80x45 mm
- Dimensions of the UHF antenna: 18 mm x 12.5 mm
- Antenna material: copper; thickness 35 µm;
- Substrate material: FR4; thickness 1.5 mm;

4.2 Measurement results

Fig 4 shows the reading distance in meters over the frequency spectrum from 840MHz till 960MHz. The blue line shows the reading distance for maximum amount of copper surface in the ground plane and the brown line shows the reading distance for minimum amount of copper surface in the ground plane. For real life applications the performance can be expected to be in the middle of the measured results (Demo board).

Note: The mounting of electronic components could cause a change in the resonance frequency and therefore this could have a negative influence on the reading distance.

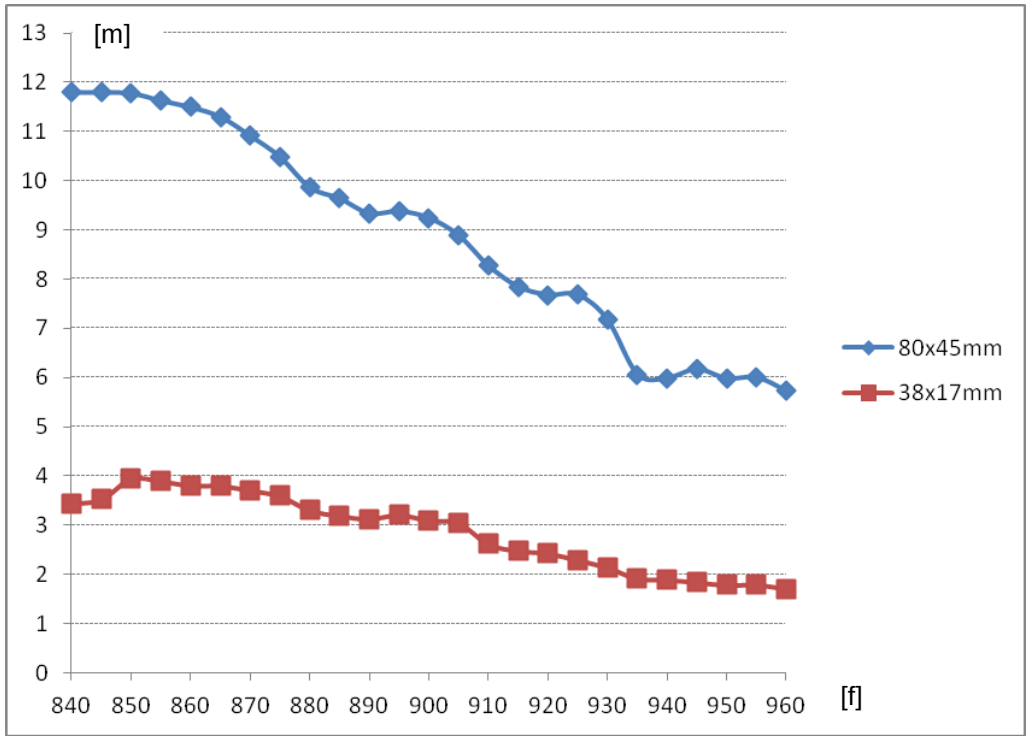

Fig 4. Large design: Reading distance in meters

4.3 Demoboard

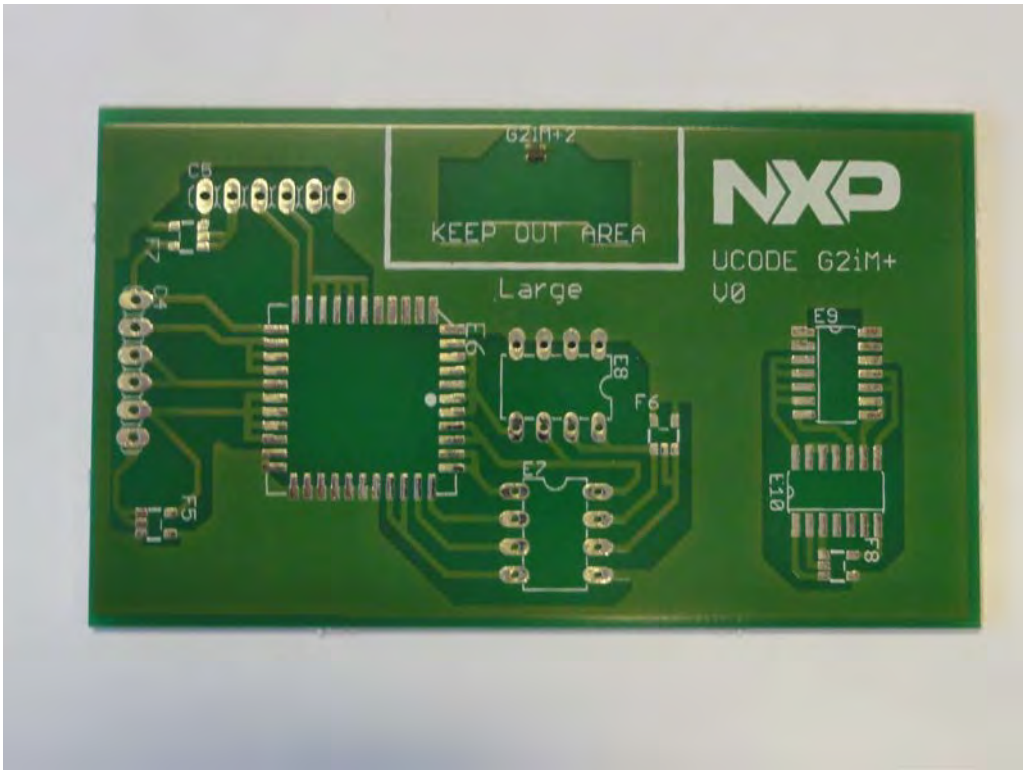

Fig 5. Demoboard with Large antenna

4.4 Demo board Measurement results

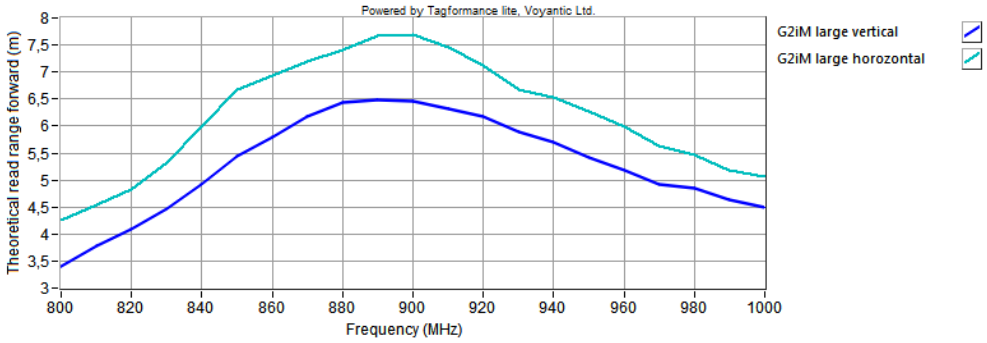

Fig 6. Measurement results Demoboard

5. Medium antenna reference design

This section describes the design of an antenna with a medium reading distance.

5.1 Antenna Geometry

The antenna is an integral part of the PCB. The brown part in Fig 7 represents the ground plane. In a real life application most of the ground plane surface will be occupied by electronic components and therefore the read/write performance may be less than the performance of this reference design antenna.

Fig 7. Medium Antenna Reference Design

Details of the antenna design:

- Dimensions of the board: 80x45mm
- Dimensions of the UHF antenna: 12.5 mm x 10 mm
- Antenna material: copper; thickness 35 µm;
- Substrate material: FR4; thickness 1.5 mm;

5.2 Measurement results

Fig 8 shows the reading distance in meters over the frequency spectrum from 840MHz till 960MHz. The blue line shows the reading distance for maximum amount of copper surface in the ground plane and the brown line shows the reading distance for minimum amount of copper surface in the ground plane.

For real life applications the performance can be expected to be in the middle of the measured results (Demo board).

Note: The mounting of electronic components could cause a change in the resonance frequency and therefore this could have a negative influence on the reading distance.

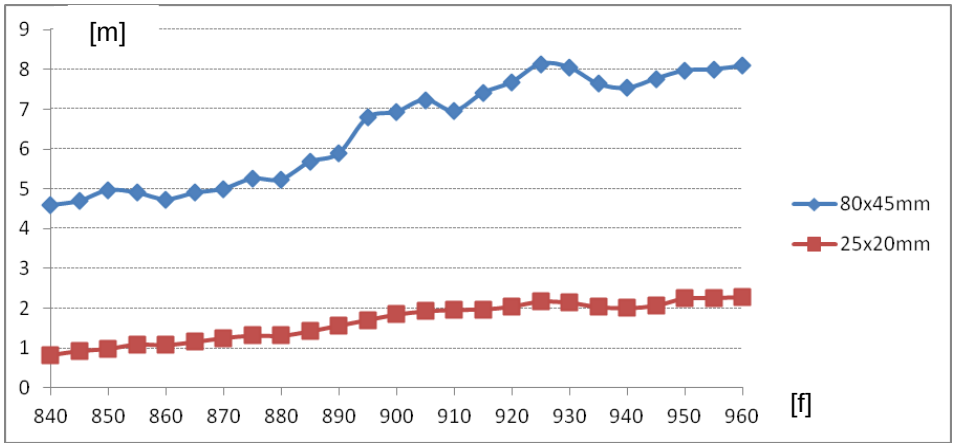

Fig 8. Medium design: Reading distance in meters

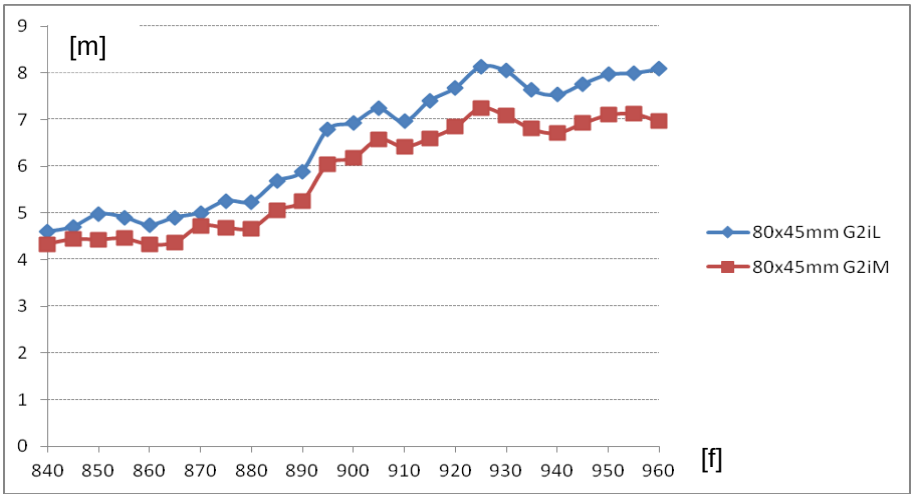

Fig 9. Medium design: Reading distance comparison in meters between G2iL and G2iM

5.3 Demoboard

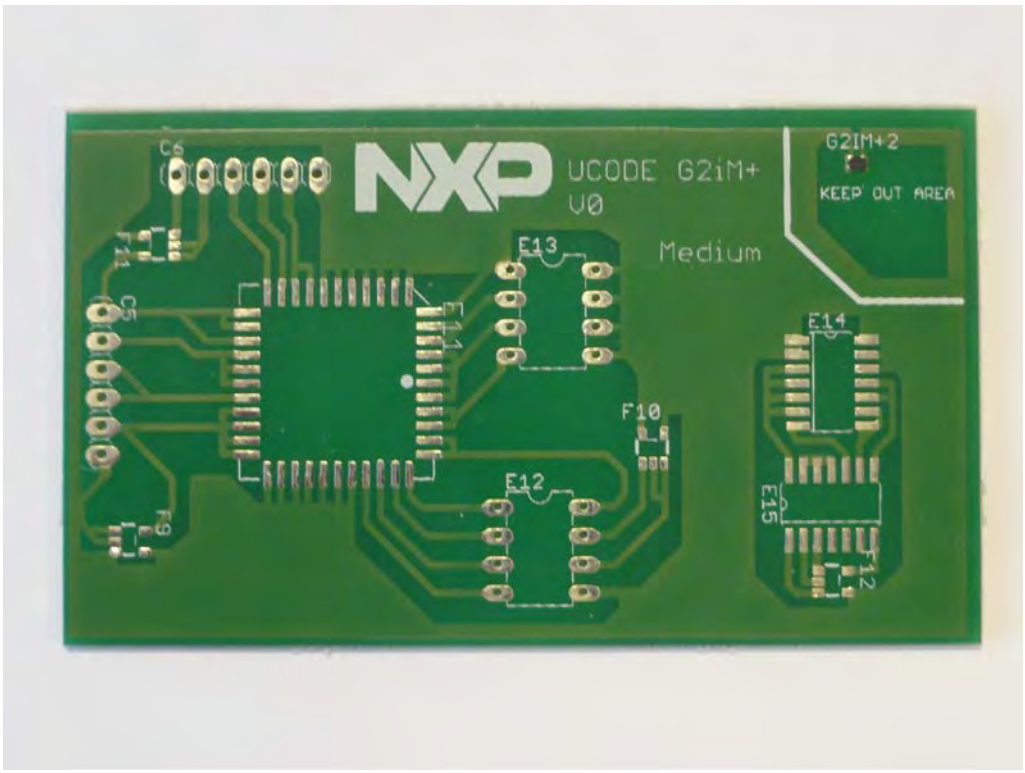

Fig 10. Demoboard with Medium antenna

5.4 Demo board Measurement results

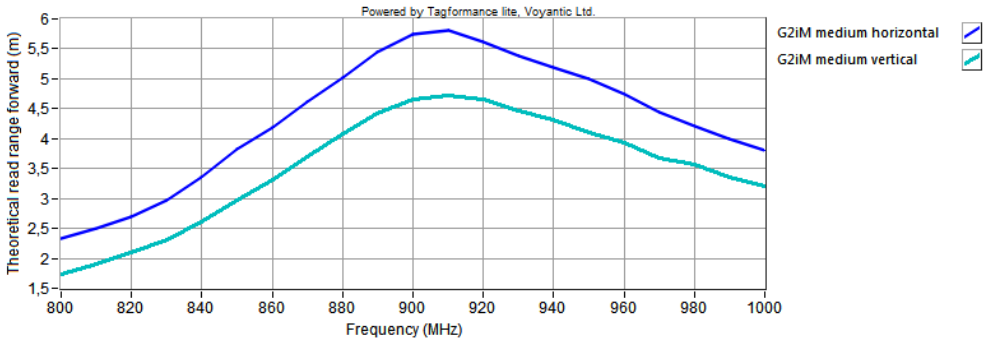

Fig 11. Measurement results Demoboard

6. Small antenna reference design

This section describes the design of an antenna with a small reading distance.

6.1 Antenna Geometry

The antenna is an integral part of the PCB. The yellow part in Fig 12 represents the ground plane. In a real life application most of the ground plane surface will be occupied by electronic components and therefore the read/write performance may be less than the performance of this reference design antenna.

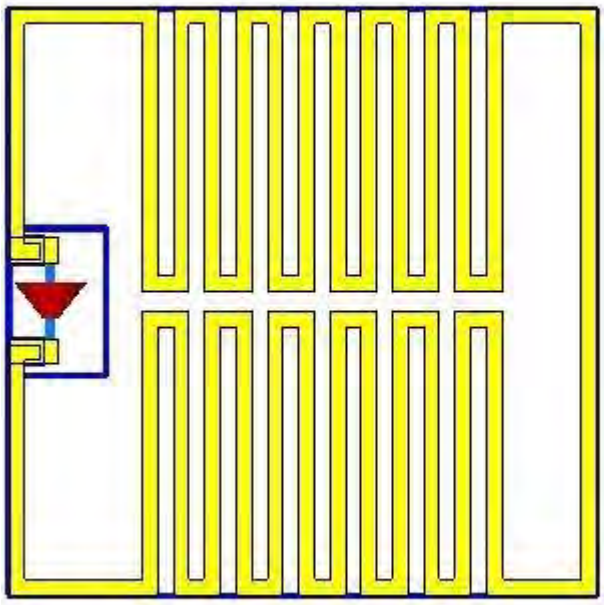

Fig 12. Small antenna design

Details of the antenna design:

- Dimensions of the board: 6x6mm
- Dimensions of the UHF antenna:
- Antenna material: copper; thickness 35 µm;
- Substrate material: FR4; thickness 1.5 mm;

6.2 Demoboard

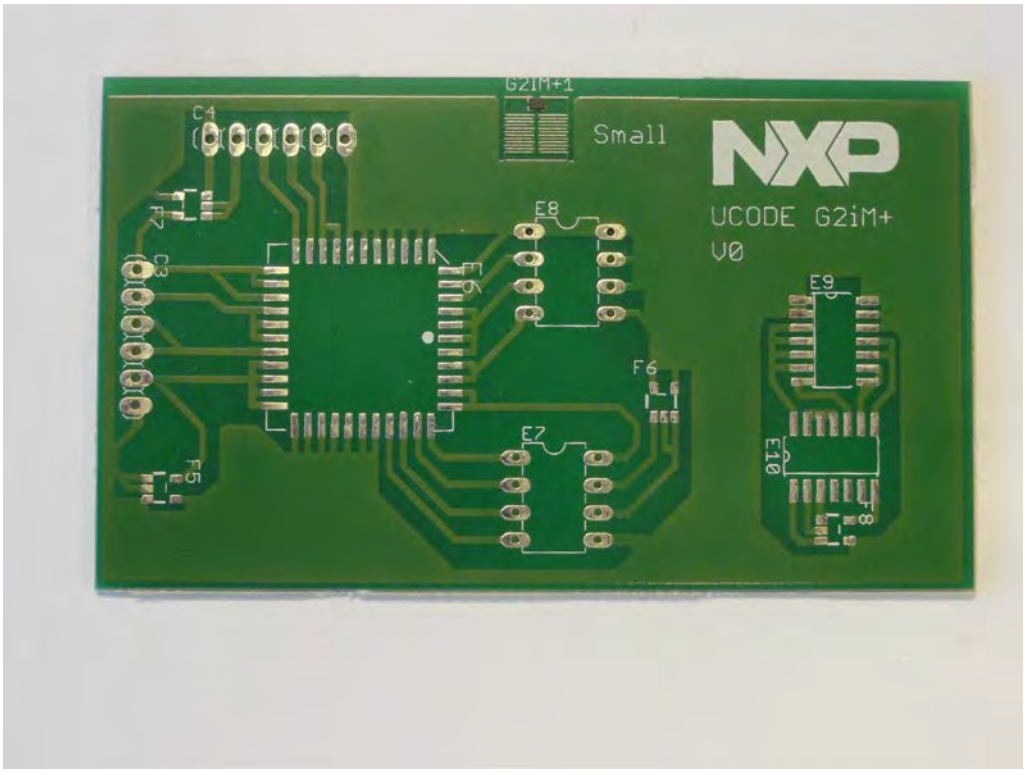

Fig 13. Demoboard with Small antenna

6.3 Demo board Measurement results

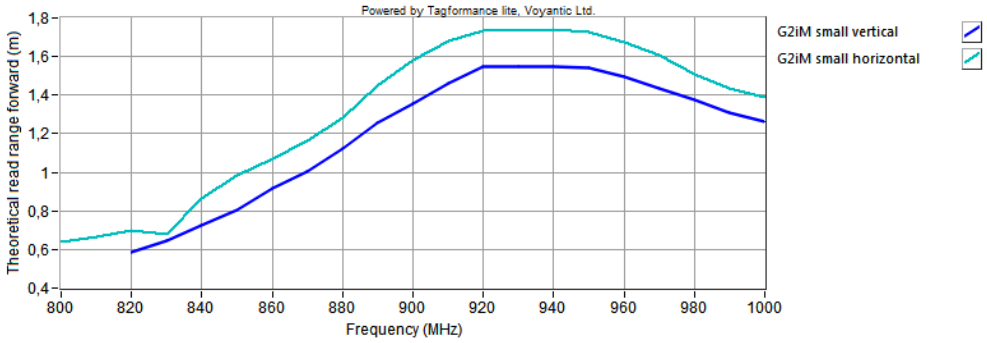

Fig 14. Measurement results Demoboard

7. References

[1] EPC™ Radio-Frequency Identity Protocols, Class-1 Generation-2 *UHF RFID, Protocol for Communications at 860MHz – 960MHz, Version 1.2.0; EPCglobal™ Inc.* http://www.nxp.com/redirect/gs1.org/gsmp/kc/epcglobal/uhfc1g2

[2] ISO/IEC 18000-1, *Information technology — Radio frequency identification for item management — Part 1: Reference architecture and definition of parameters to be standardized*

[3] ISO/IEC 18000-6, *Information technology — Radio frequency identification for item management — Part 6: Parameters for air interface communications at 860MHz to 960MHz*

[4] Data sheet, SL3S1203_1213; UCODE G2iL and G2iL+ (BLID 1788) http://www.nxp.com/documents/data_sheet/SL3S1203_1213.pdf

[5] Data sheet: SL3S1003_1013; UCODE G2iM and G2iM+ (BLID 2012) http://www.nxp.com/documents/data_sheet/SL3S1003_1013.pdf

[6] Application note: AN10940; FAQs on G2i http://www.nxp.com/restricted_documents/53420/AN10940.pdf

[7] Application note: AN11237 UCODE G2iM+ Demoboard Documentation

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