AN10906

Starter guide PCB tagging

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Application note
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Document information

Info	Content
Keywords	UCODE EPC G2, G2XM, G2XL, Reference Design, Antenna Design, PCB
Abstract	This paper describes two basic methods to design RFID UHF antenna on a PCB.

founded by Philips

Revision history

Rev	Date	Description
2.0	20100121	Modifications: Figure 1 to Figure 7, Table 1, Table 3
1.0	20091214	First release

Contact information

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1. Introduction

Radio Frequency IDentification (RFID) has rapidly got attention in many commercial applications, such as supply chain managements, retail store applications and tracking goods. For Ultra High Frequency (UHF) passive RFID systems, the tags must have a good impedance matching to achieve maximum power transfer between the tag IC and the antenna.

Normally, UHF RFID tags are applied to an object once the assembly is complete. Manufacturers want item level tracking at the beginning of the Printer Circuit Board (PCB) assembly. The following points should be considered before designing a tag on a PCB.

1) Tracking method should be compatible with current information systems while providing privacy and security.

2) It should be low cost, enough to provide a positive return on investment.

3) Tracking method should be easy to modify

4) Capable of bearing Electro Static Discharge (ESD).

5) Should be functional within finished goods and compatible across all industries.

This document is a practical approach to RFID PCB tagging showing two different concepts of PCB antennas, the slot and the loop antenna, both based on UHF Passive RFID technology and can be easily etch on a PCB.

NXP offers new approach allowing implementation of the RFID tag directly on to a PCB early in the production process. A small UHF RFID chip package (size 1 x 1.45 x 0.5 mm) is mounted on the PCB with matching copper antenna etch on the PCB act as an UHF tag.

Objective of this document is to provide a unique approach and guideline for implementing RFID onto a PCB. The read range results are indications, and may change depending on components assembled on the board and reading environment.

For detail theoretical background you may like to read NXP Semiconductors Application Note, “Application Note 1715xx UHF RFID PCB antenna design”.

2. Example: Slot antenna

Main concept of slot antenna design is to add a slot in the metal (copper) area of the PCB. This will make the entire PCB act as the effective antenna area. The length and the width of slot will determine the inductance impedance of slot antenna. The performance of the PCB antenna, in this case read range, will depend on how well the PCB antenna impedance is matched with the capacitive impedance of the packaged IC.

In applications where reduced performance is acceptable the slot can actually be placed asymmetrically on the PCB with various turns as shown in the next antenna example. For simulation results please refer to “Application Note 1715xx UHF RFID PCB antenna design”.

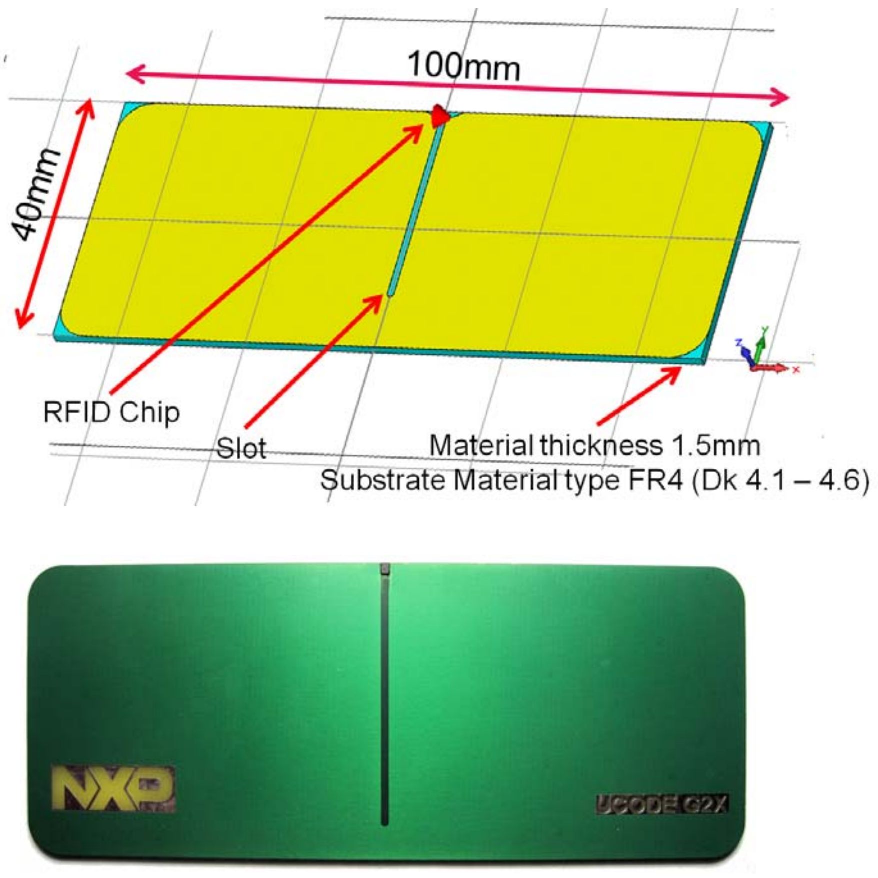


Fig 1. Layout of NXP PCB reference design

The following steps should be consider before designing slot antenna on a PCB

1) **Antenna area requirement:** The size of the effective antenna area (copper layer) on a PCB should be at least 5 times the slot width (W). In other words, on each side of the slot there should be at least a metallization area of 2*W each.

2) **Width area clearance:** No vias and components should be placed in an area surrounding 2 mm of the slot antenna, due to the high density of the magnetic field strength.

3) **Slot dimension:** Changing the slot dimension and placement will decrease the optimum performance. The ideal slot dimensions will also depend on the substrate (thickness and material). Details on this topic can be found in the "Application Note 1715xx UHF RFID PCB antenna design". It is not necessary to design slot antenna in one dimension. Slot antenna can be design by turning the angle of the antenna in various directions. The resulting performance is shown in the next chapter of this document.

Fig 2. Prototypes: 2 versions of the reference designs (vary in slot length)

Table 1. Properties slot antenna reference design

Layers	1 (single layer)
PCB Dimension	100 mm x 40 mm
Slot	2 different slot sizes (34,5 mm and 31,4 mm)
Substrate	FR4
Substrate thickness	1. 6 mm
Antenna material	Copper
Antenna material thickness	35 µm

Read Range:

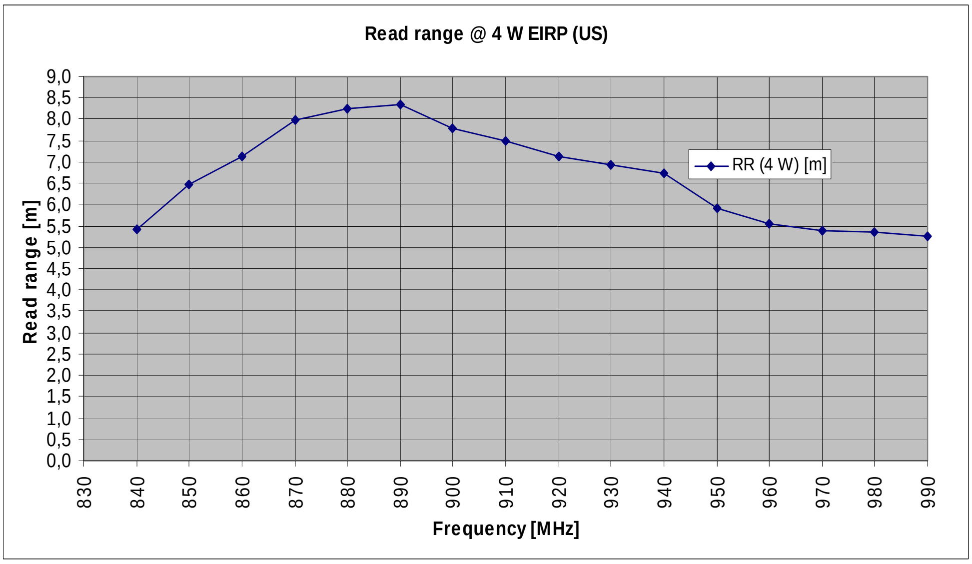


Fig 3. Calculated read range for the US tuned PCB (FCC regulation)

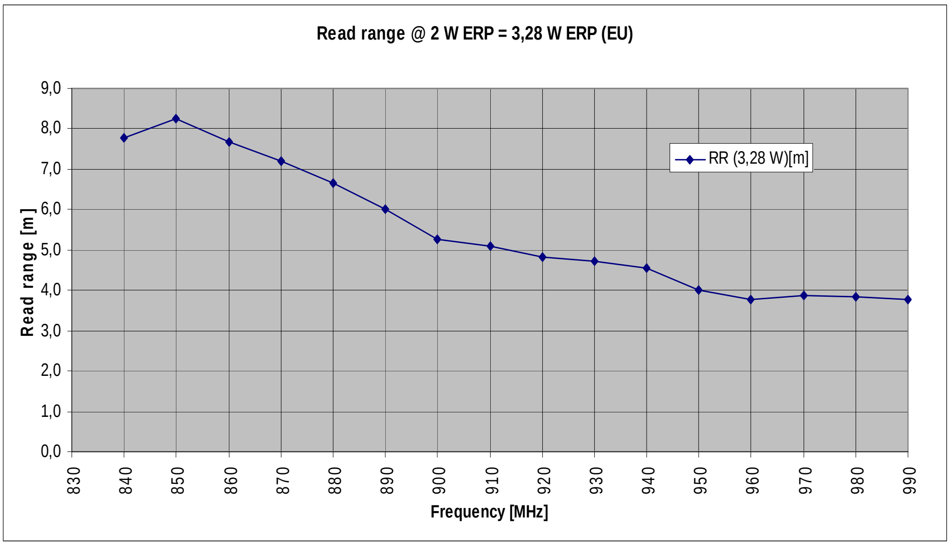


Fig 4. Calculated read range for the EU tuned PCB (ETSI regulation)

3. Example: Generic phone board

This is an example of Generic Phone Board PCB where straight slot antenna design is not possible due to limited space on the board. In order to achieve still an antenna with acceptable performance, we have designed slot antenna with longer slot length. The length of the slot antenna is increased due to reduced thickness of the substrate and turns on the antenna slot.

More detail information related to proportion between slot dimension and substrate thickness can be found in “Application Note 1715xx UHF RFID PCB antenna design”, Chapter 5.

Table 2. Types

Label Type	Generic phone board reference antenna
IC Type	NXP UCODE G2X SOT1122

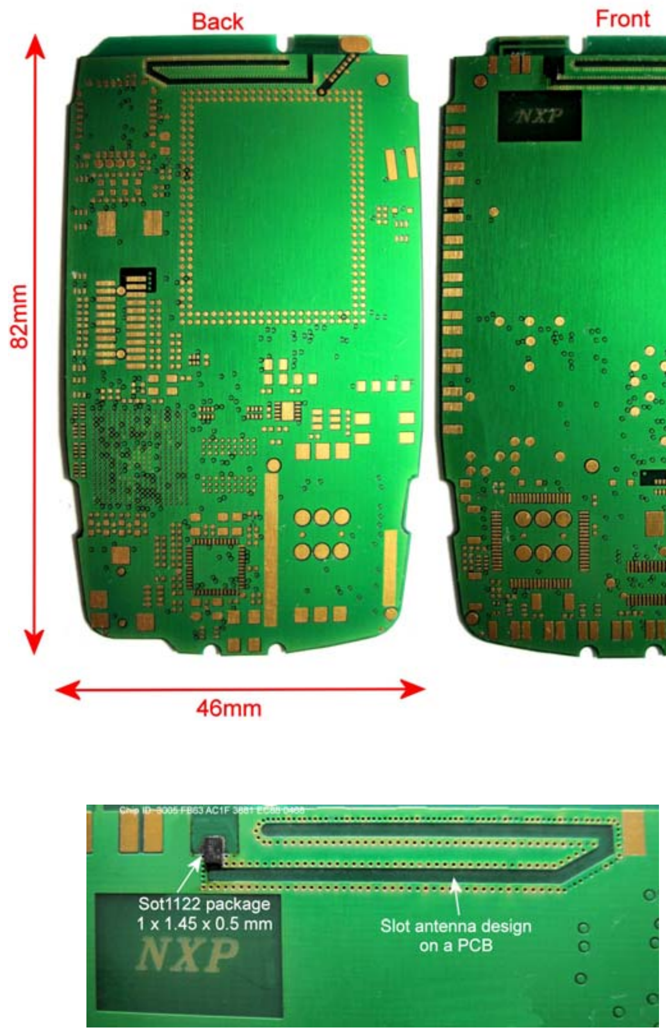
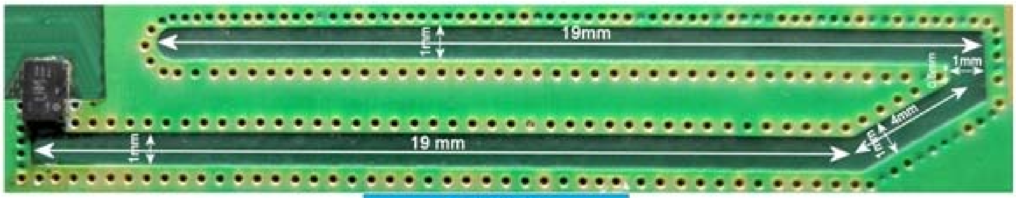


Fig 5. NXP generic phone board, front side and back side



Slot area		
Area 1	19 x 1 mm	19 mm²
Area 2	4 x 1 mm	4 mm²
Area 3	1 x 0.5 mm	0.5 mm²
Area 4	19 x 1 mm	19 mm²
	Total area	42.5 mm²

Fig 6. Detail: Slot area generic phone board

Table 3. Properties generic phone board reference design

Layers	4
PCB Dimension	46 mm x 82mm.
Substrate	FR4
Substrate thickness	120 µm FR4 between copper layer 1 and layer 2 200 µm FR4 between copper layer 2 and layer 3 120 µm FR4 between copper layer 3 and layer 4
Slot area	42.5 mm^2
Total slot length	42.5 mm
Total slot width	1 mm
Antenna material thickness	35 µm
Antenna material	Copper

Read range:

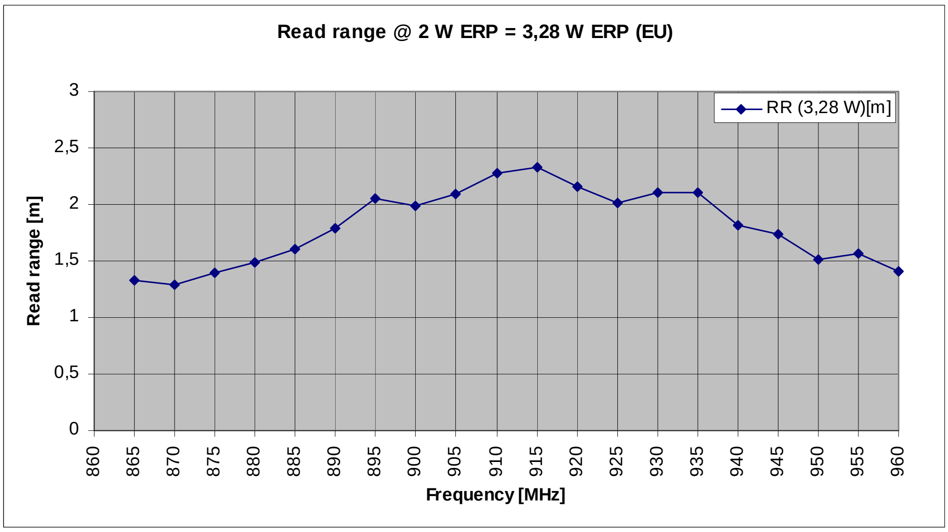


Fig 7. Calculated read range (ETSI regulation)

Fig 7 shows a read range of more than 2 meters for the USA frequency band, and more than 1 meter for the European frequency band. This is a performance drop compared to the slot shown in the first example, which shows a read range of up to 8 meters. This drop has two main reasons:

1) Asymmetrical placement: This reduces the gain of the antenna and therefore also the read range.

2) Bending of the slot: The target of this antenna was to fit the slot in an existing design, the drawback of the bending is the reduced read range due to increased losses.

4. Example: Loop PCB

This example is based on following concept:

The IC is connected to a loop, which matches the impedance of the packaged IC. The final read range is depending on where this loop is implemented on the board. The area of the loop in this example is 5 mm x 5 mm, and it is implemented over 4 PCB layers. Detailed pictures of the loop, and also investigations of the read range performance are contained in the “Application Note 1715xx UHF RFID PCB antenna design”.

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6. Contents

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