On The Effect of Mutual Coupling on LF and UHF Tags Implemented in Dual Frequency RFID Applications

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Topics

- Introduction
- Dual frequency tag
- Test setup
- Test results
- Discussion
- Conclusion

Introduction

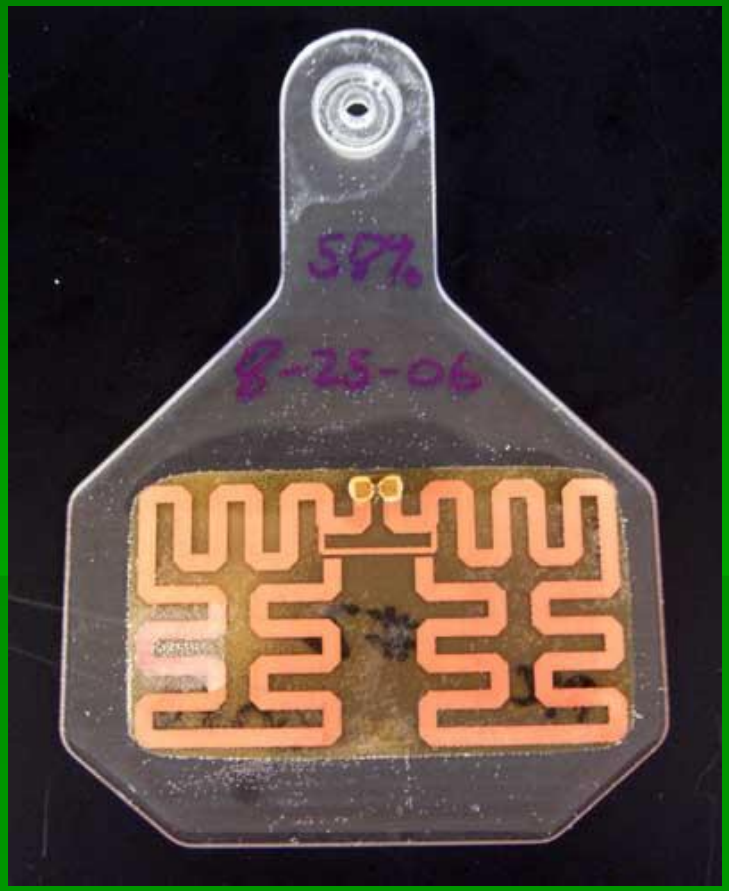
- Interest in RFID has recently grown tremendously in many areas [1]-[5]:
  - supply chain management [6]-[8]
  - RFID security [9]-[10]
  - UHF antenna design [11]
  - back-scattering analysis [12]-[14]
  - dual frequency applications
- Types of systems [1]
  - passive
  - semi-passive
  - active

Introduction

- On a passive tag the antenna is typically connected directly to the rectifier.
  - thus antenna impedance and rectifier impedance directly effect the read range
- Antenna characteristics (gain, input impedance and resonant frequency) can be effected by nearby conducting and non-conducting objects [15]-[21]:
  - Weather-proof enclosures
  - Surface placement of tag
  - Other RFID tags (i.e., dual-frequency tags)

Introduction

- Several advantages are gained by using a weather-proof enclosure [18]:
  - Protection against heat, physical damage, and the environment (moisture, sun)
  - Dual-frequency implementation
- Several examples include:
  - Electronic car tolling [22]
  - Livestock tracking [23]-[24]



A Little Background

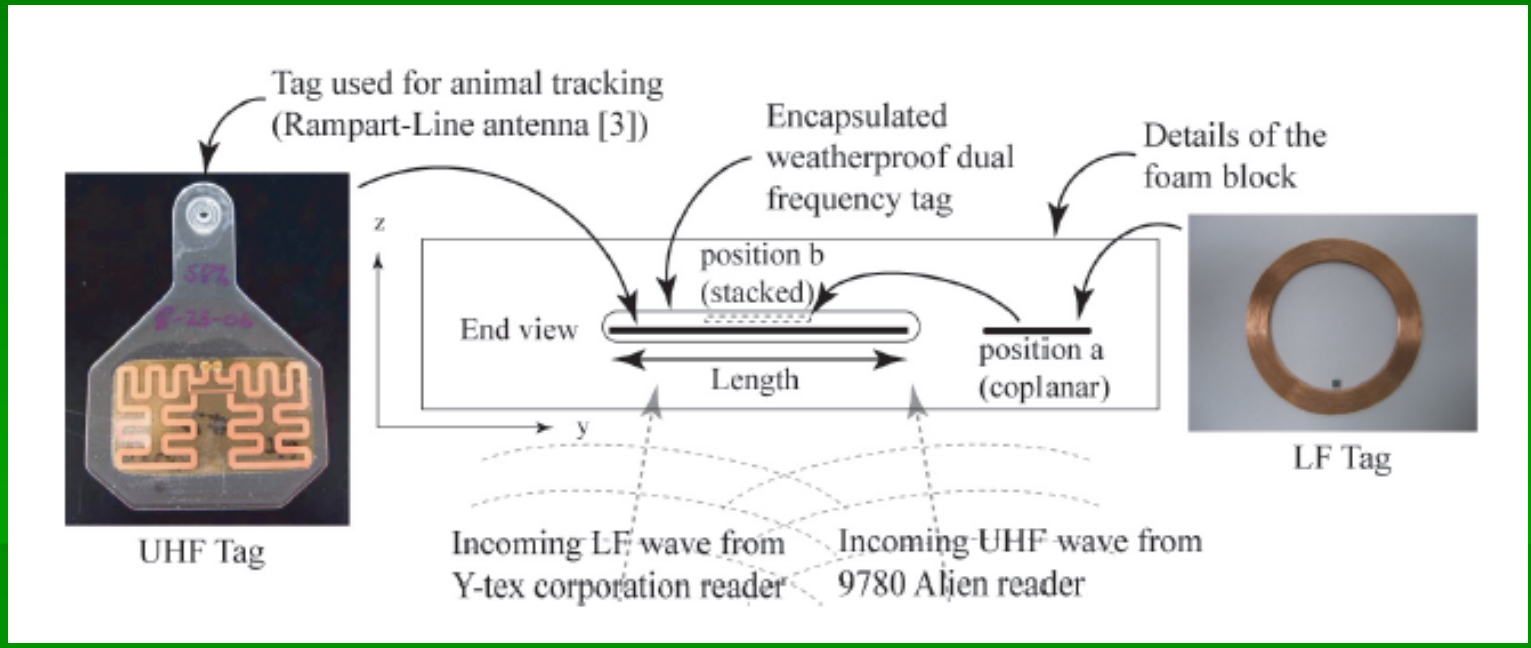
- The max theoretical read range of a passive RFID tag can be written as (using Friis's eqn.) [25]:

$$r_{max} = \frac{\lambda}{4\pi}\sqrt{\frac{P_t G_t G_r (1 - |s|^2)}{P_{th}}}$$

where

$$|s|^2 = \left|\frac{Z_L - Z_A^*}{Z_L + Z_A}\right|^2$$

The Dual-Frequency Tag and Test Setup



(902-928MHz)

(125.4-134kHz)

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Test Setup

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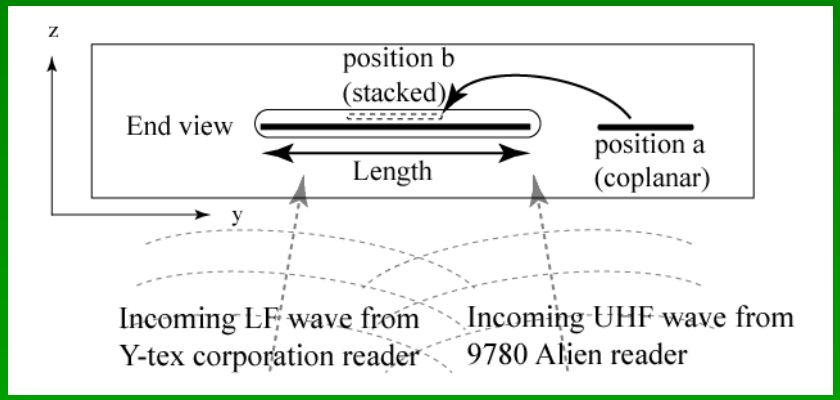
Test Results

Table 1: LF tag read range impact with Rampart UHF tag present.

Plane	coplanar	stacked
xy	-1.24 %	-3.00 %
yz	+13.09 %	-5.07 %
xz	0.00 %	-5.77 %

(reminder)



← LF tag

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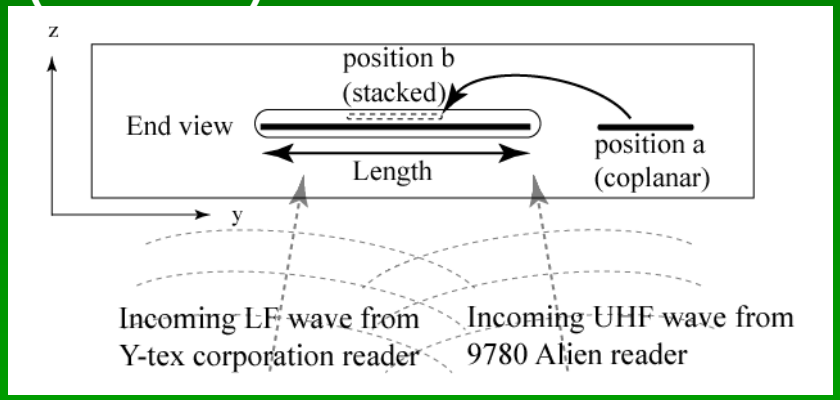
Test Results

Table 3: M-tag read range impact with LF tag present.

LF coord.	z=0in	z=-1in	z=-2in
(0,0)	-67.27%	3.17%	5.39%
(0,.5)	14.26%	3.17%	2.06%
(0,1)	-1.27%	2.06%	3.17%
(0,2)	-.44%	2.06%	4.56%
(0,3)	2.89%	1.51%	4.28%
(1,0)	-2.1%	1.51%	3.17%
(-1,0)	-2.56%	3.45%	-.9%

(reminder)



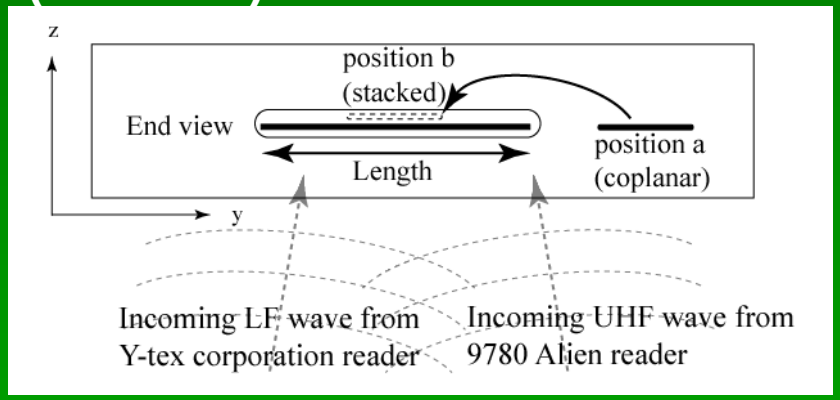
← M-tag [33]

Test Results

Table 4: Squiggle tag read range impact with LF tag present.

LF coord.	z=0in	z=-1in	z=-2in
(0,0)	-10.88%	.68%	-1.02%
(0,.5)	-91.84%	-.68%	-1.02%
(0,1)	-67.35%	1.02%	-.68%
(0,2)	-66.67%	0%	-.68%
(0,3)	-.45%	-2.04%	0%
(1,0)	-2.38%	-.34%	-2.04%
(-1,0)	.68%	-.68%	-1.36%

(reminder)



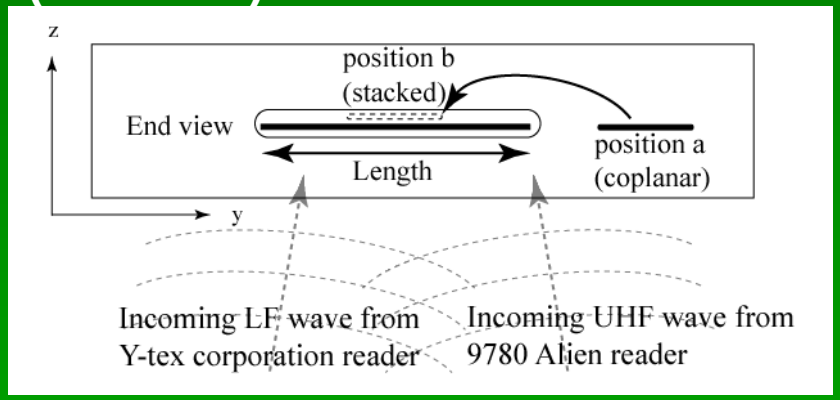
Squiggle Tag [33]

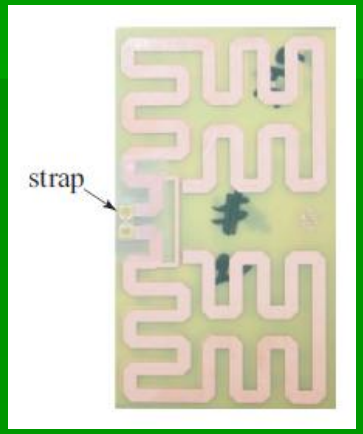
Test Results

Table 2: Rampart tag read range impact with LF tag present.

LF coord.	z=0in	z=-3in	z=-7in
(0,0)	11.73%	-1.00%	-1.02%

(reminder)





← Rampart tag [29]

Discussion

- Table 3 showed that a LF tag placed directly on the M-tag reduced the read range by 67.27%.
- Table 4 showed that the LF tag placed near the squiggle tag reduced the read range by 91.84%.
- The Rampart-line was less affected by the LF tag.

Discussion

- In all cases by moving the LF tag to the edge of the UHF tags the read range could be recovered.
- The trade-off to moving the LF tag to the edge of the UHF tag is a larger footprint.

Conclusion

- A dual frequency (UHF and LF) tag has been introduced.
- The read range of each tag was determined in the presence of mutual coupling.
- In several instances the read range of the UHF tag was substantially decreased (91.84%).

Conclusion

- In all instances is was shown that most of the read range could be recovered by moving the LF tag to the same plane of the UHF tag

Questions

Thank you for listening

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