RFID UHF tag Antenna design

Gert Doodeman
TNO Science and Industry
The Netherlands

The main parameters

- **Frequency range : ~ 860 – 950 MHz**
- **Chip impedance : highly capacitive**
- **Radiation diagram : non directive**

The challenge is to have an impedance match over the whole required frequency band

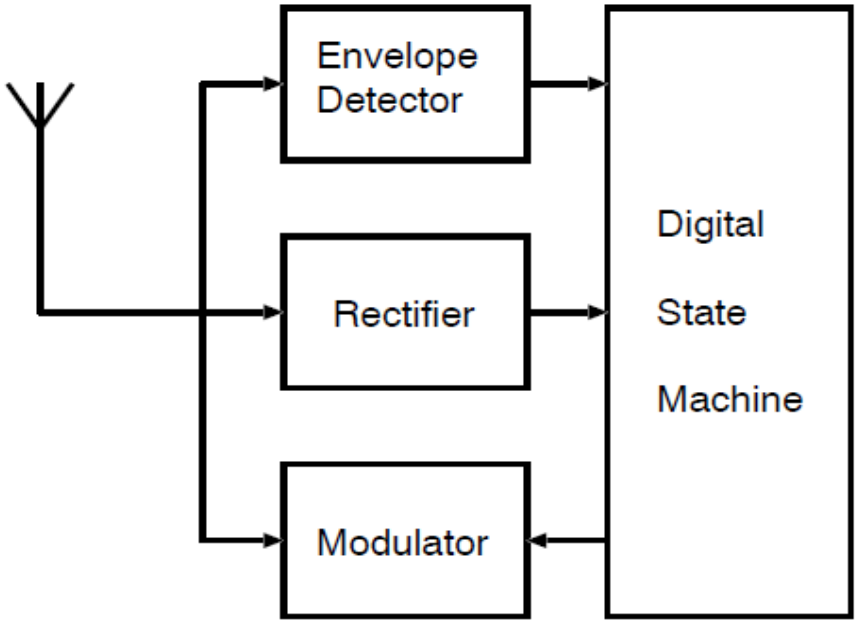
The chip and the chip impedance

UHF RFID chip is a very simple circuit:

- No RF circuitry
- Absorbtion modulation with subcarrier
- Backscatter by subcarrier

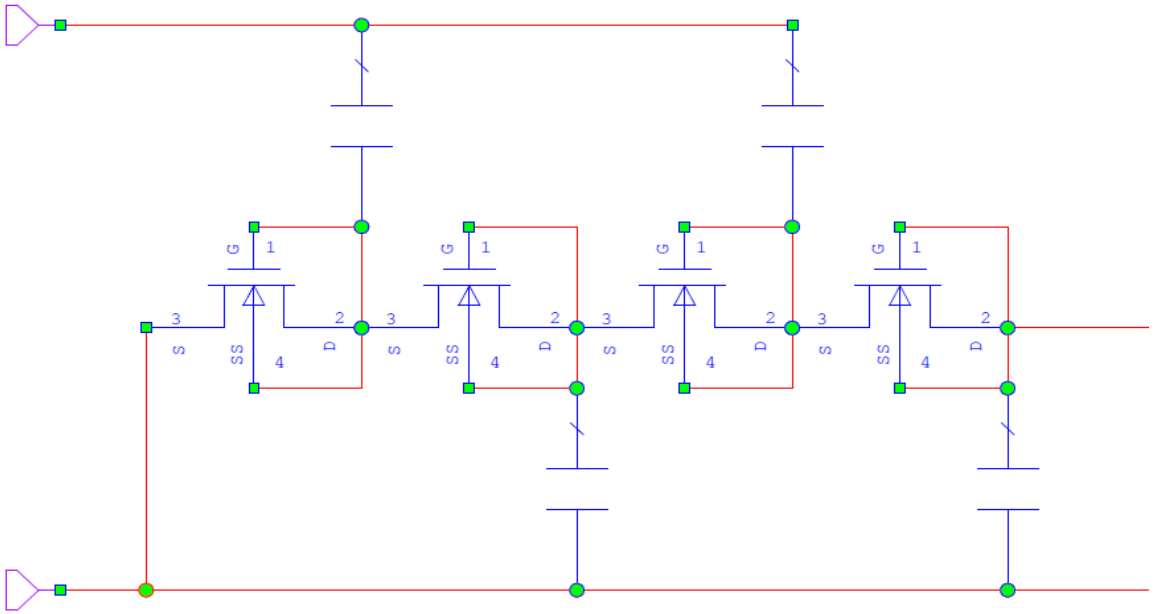
Disadvantage

- No impedance match



The chip and the chip impedance

The DC rectifier circuit (Dickson Voltage Multiplier)



The impedance depends on the RF signal level. Both real and imaginary part.

A DC short in the antenna is needed.

The chip and the chip impedance

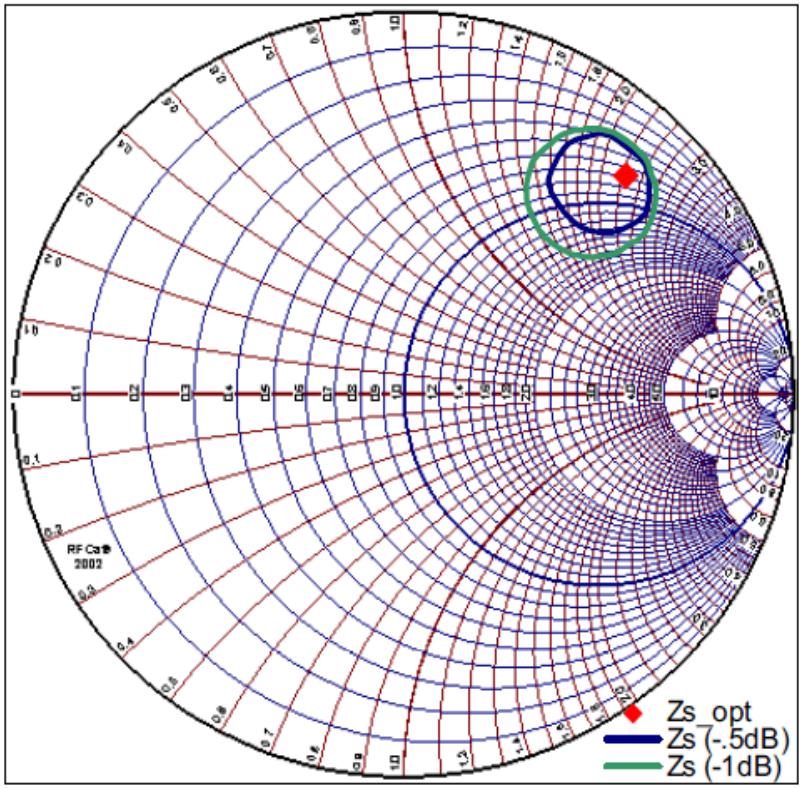
Look for impedance at the threshold power level.

Example: Impinj Monza chip

850 MHz: 36 + j 117 Ω

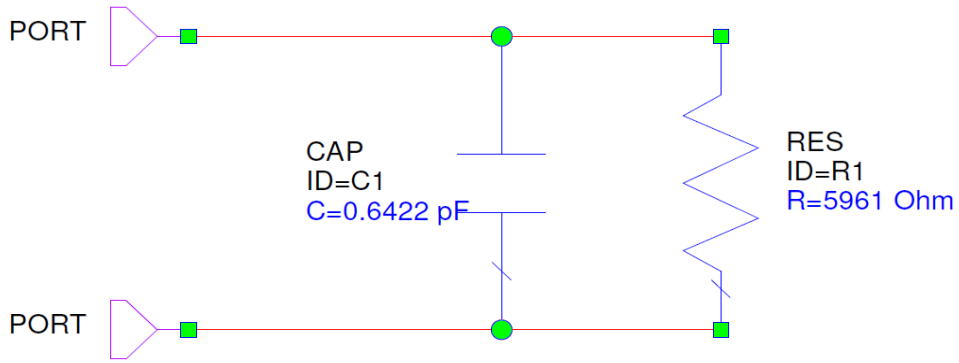
900 MHz: 33 + j 112 Ω

950 MHz: 30 + j 108 Ω



The chip and the chip impedance

The chip model for the threshold power level:



The real part depends on the RF power level.

The capacitor is less dependent.

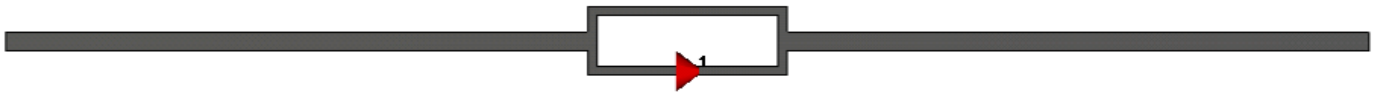
The basic antenna design

Design steps

1. Decide for which application the RFID tag will be used

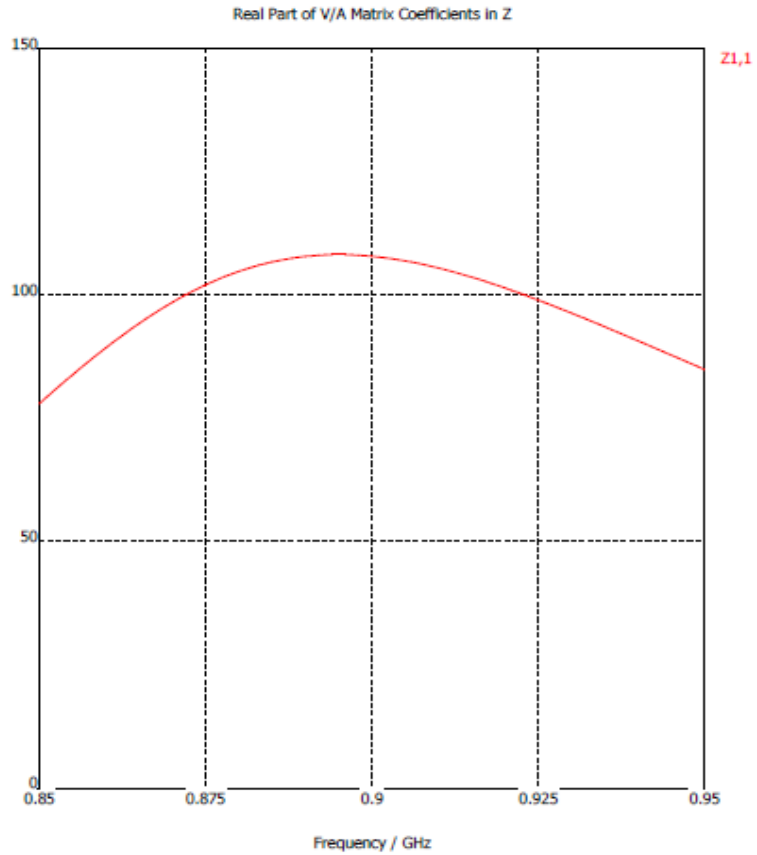
2. Start with a dipole antenna

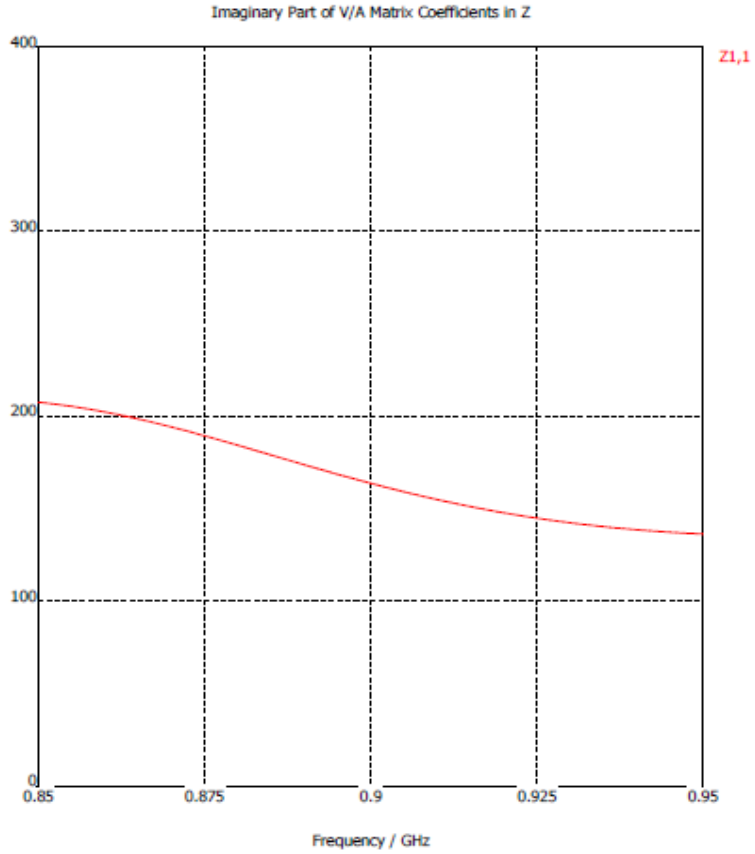
3. Add an inductor to match with the capacitive load and creating the DC short



The basic antenna design

Antenna impedance of this simple design



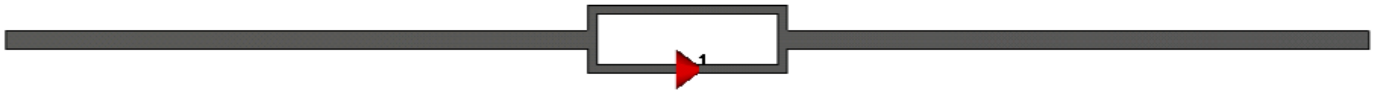


The slope of the imaginary part acts like a negative capacitance

Tuning the basic antenna design

Parameters to tune : the shape of the inductor

1. The width of the inductor gap

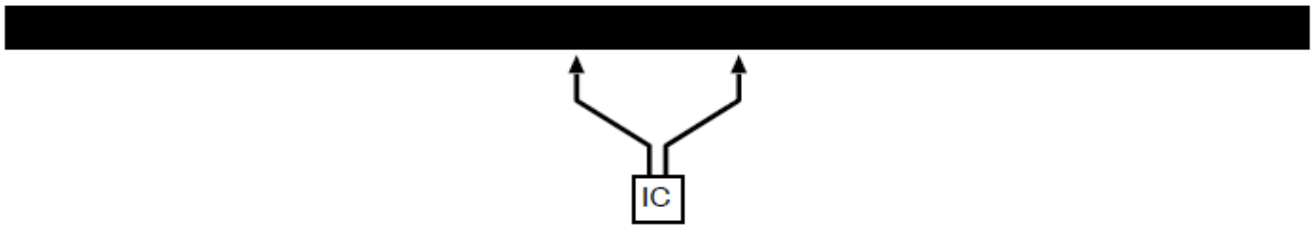


L	W	850 MHz	900 MHz	950 MHz
10	4	7 + j 70	14 + j 71	16 + j 68
10	6	15 + j 96	26 + j 94	27 + j 87
10	8	23 + j119	40 + j 113	40 + j 101
	Goal	36 + j117	33 + j113	30 + j108

Alternative antenna idea

A resonant $\lambda/2$ antenna with a γ match:

- Real part op impedance depends on position of connections
- Imaginary part of impedance is inductive

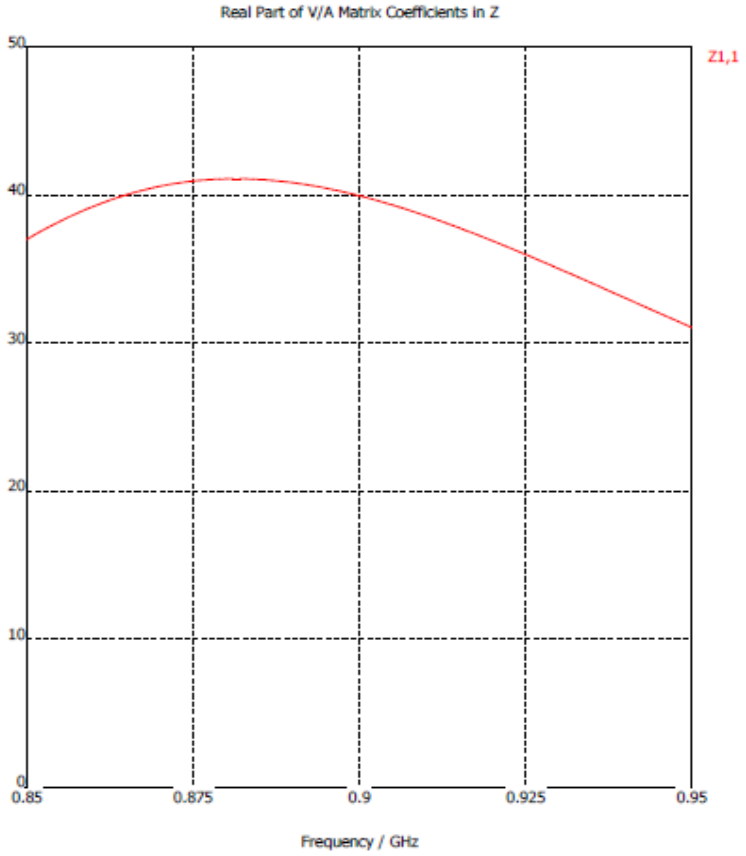


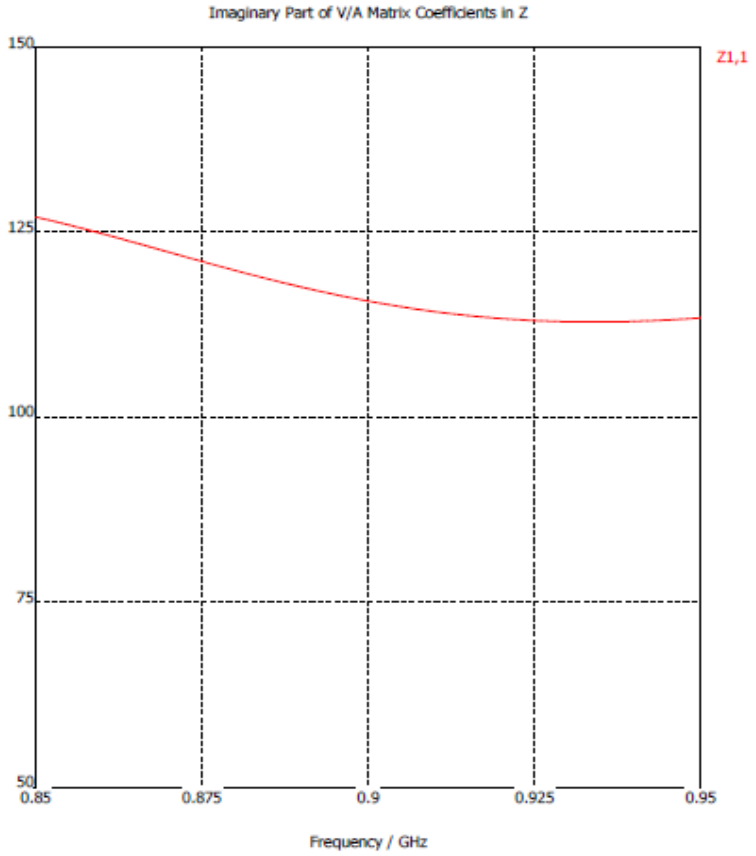
Combine it in a single radiating element

How the tune the serial inductance?
Can I use the same “negative capacitor” effect?

Alternative antenna idea in CST

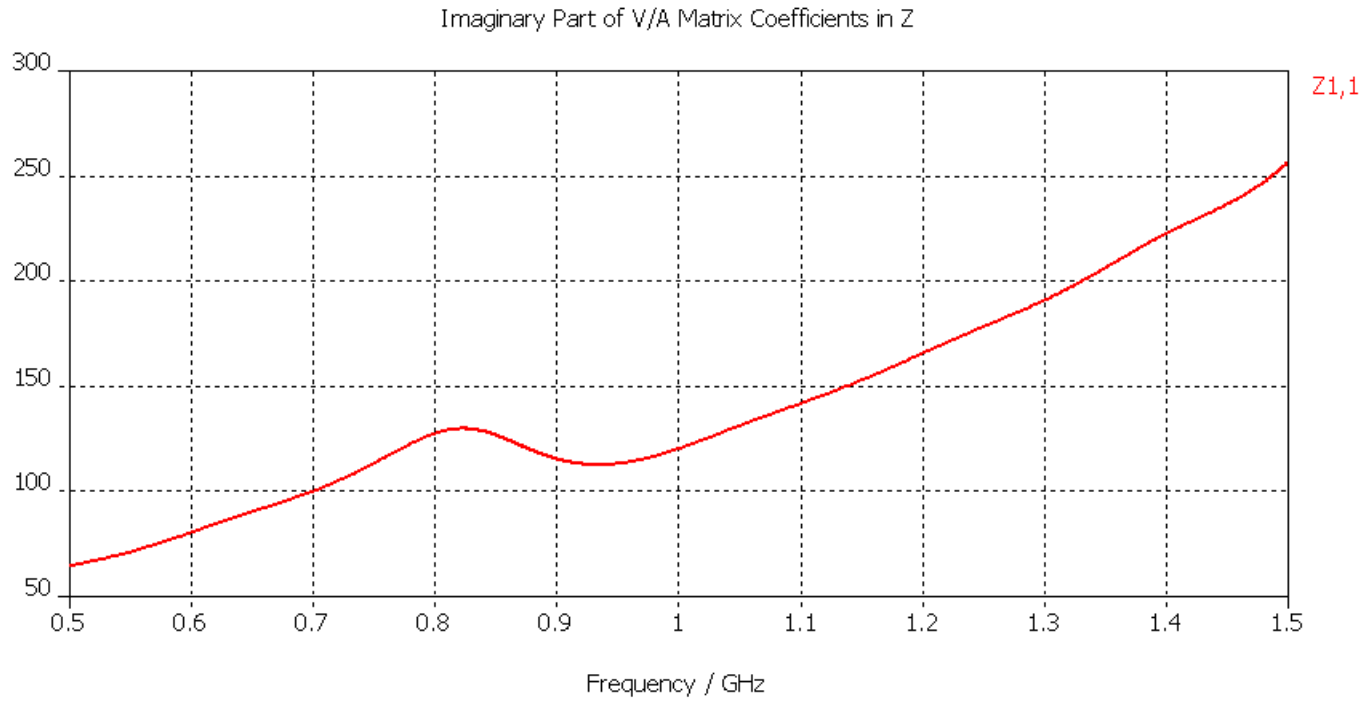
Goal 850 MHz 36 + j117 Ω, 900 MHz 33 + j113 Ω, 950 MHz 30 + j108 Ω





The alternative antenna design

The “negative capacitor” effect at the resonant frequency

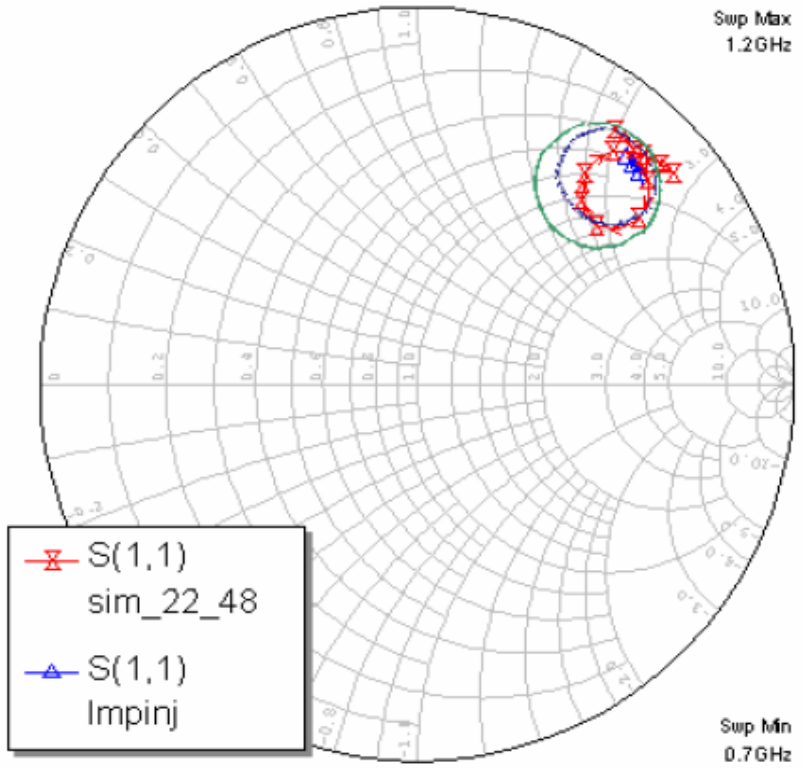


In the frequency range of the application, the imaginary part of the impedance compensates the capacitance of the chip.

The alternative antenna design

The alternative design, optimized for the substrate and carrier material.

Impedance compared to specified impedance by Impinj and measured Impinj Monza 2 chip input impedance.



Conclusion

The environment in these simulations is vacuum.
Next step is to adapt the design on the material the tag will be used with.

- The substrate
- The carrier material

Basic parameters to tune the RFID-tag

1. Length of the dipole
2. Length of the inductor gap
3. Width of the inductor gap

And finally: give it a design look and, if needed, miniaturize