Centre d'Investigació en Metamaterials per a la Innovació en Tecnologies Electrònica i de Comunicacions

Chipless-RFID Sensors for Motion Control Applications

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URSI GASS 2020, September 2020, Roma (Italy)

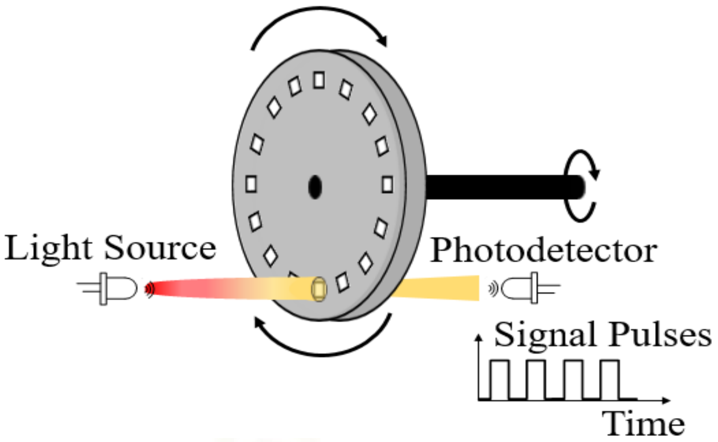
Outline

1. Motivation & Objectives
2. Working Principle
3. Reader and Encoder
4. Fabrication and Measurement
5. Conclusion

1. Motivation & Objectives

In **Motion Control applications** it is often required to use a huge amount of sensors in order to determine velocity, acceleration, displacement, among others magnitudes.

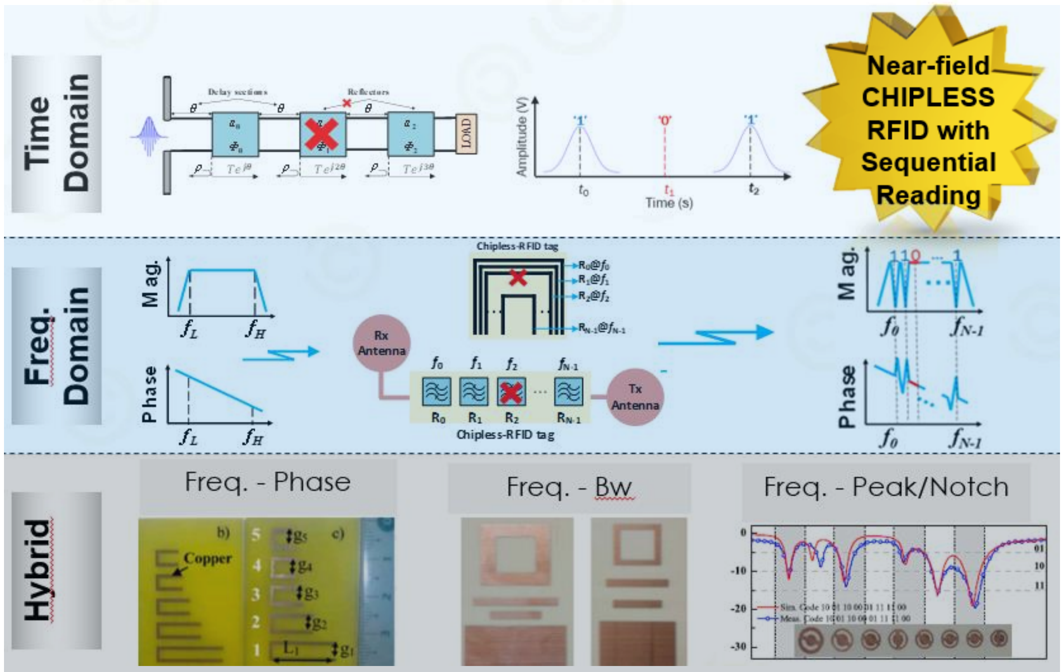
Most of such sensors are based on **optical technology**, where by counting the apertures in the encoder the position can be determined (***incremental position***)



1. Motivation & Objectives

The main objective of this work is to implement a **microwave sensor**, to measure displacement & velocity/acceleration, based on the functionality of optical encoders.

The system is inspired by the **Near-Field Chipless-RFID approach**.



The Microwave Sensor:

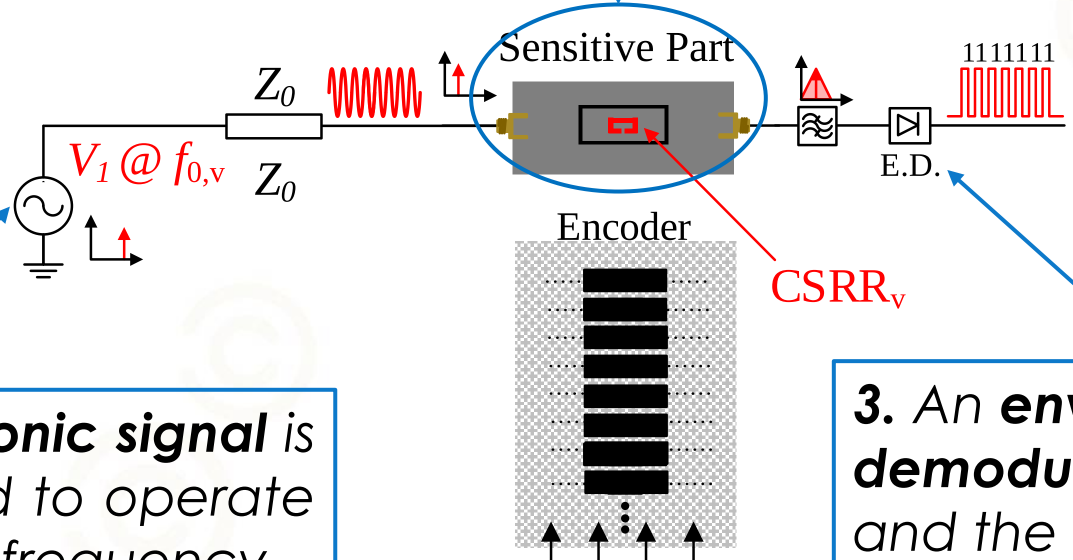
- Designed on a PCB (planar technology)
- Provide the absolute position (Bruijn)

Outline

2. Working Principle

The proposed system has the same **working principle** that **Near-Field Chipless-RFID:**

2. *At the sensitive part of the reader, the* ***encoder motion modulates*** *the injected signal.*



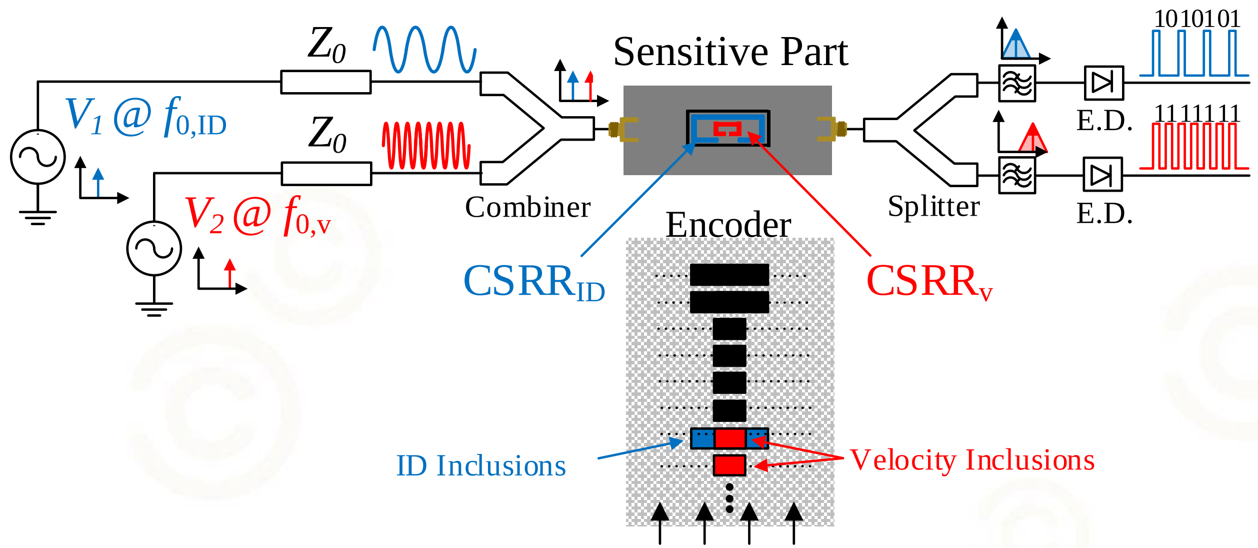
1. *A* ***harmonic signal*** *is generated to operate at certain frequency*

3. *An* ***envelope detector demodulates*** *the signal and the code is obtained*

2. Working Principle

For **Synchronous reading** it is required to have at least a **pair of harmonic signals** (V_1 & V_2 pure tones) ➔ Therefore, **two sensing elements** in the sensitive part of the **reader** are needed.

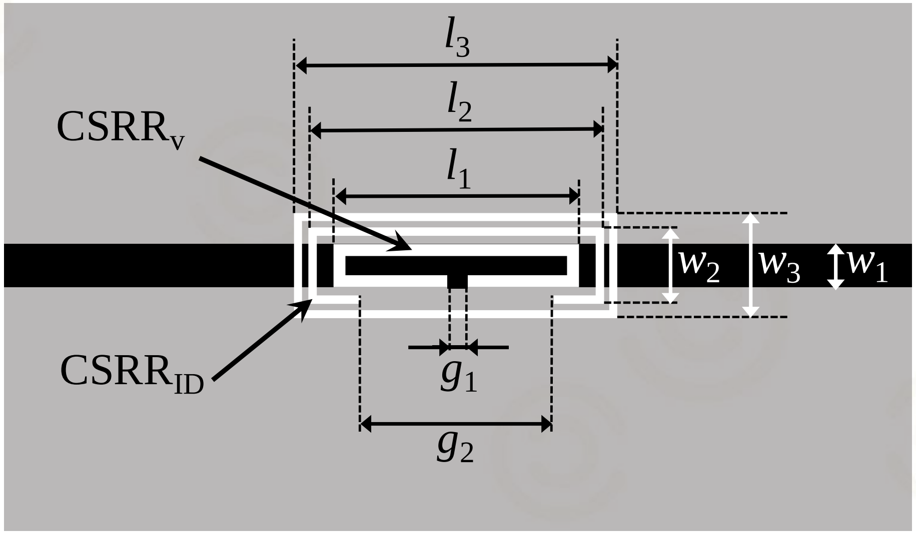
On the **encoder,** only **one chain of metallic patches** is employed in this approach and the binary states can be distinguished according the **patch size (width).**

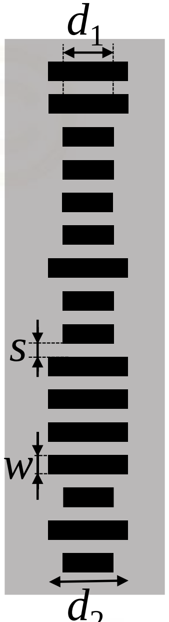


Outline

3. Reader & Encoder

The **Sensitive Part** of the reader consists of Microstrip Transmission Line loaded with **two CSRRs**, and an outer ring for tailoring the Q *factor*.





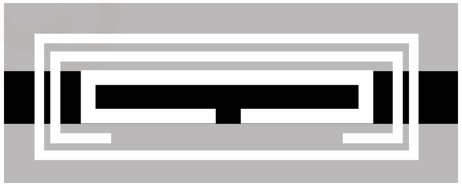
The **Encoder** is made of **metallic patches**.

The **presence** of the patch is used for **synchronous** purposes, as well as to obtain the **velocity**.

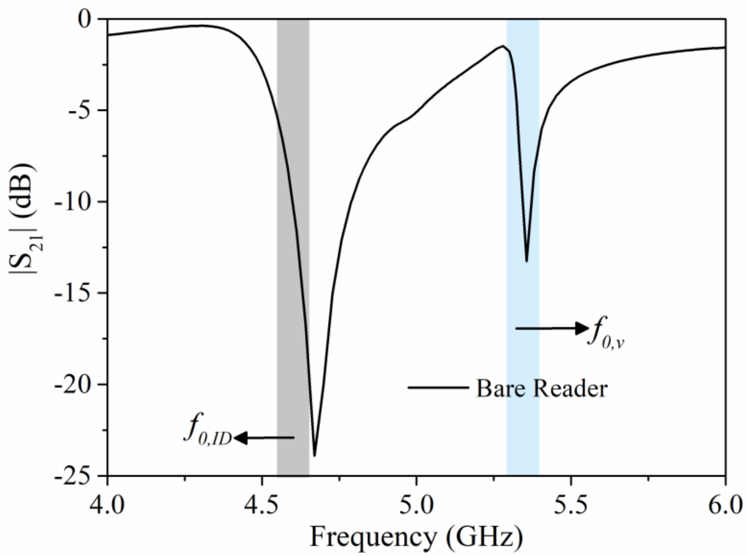
The **binary states** are associated to the **patch size**. The wider and narrow patches correspond to ‘1’ and ‘0’, respectively.

3. Reader & Encoder

Sensitive Part

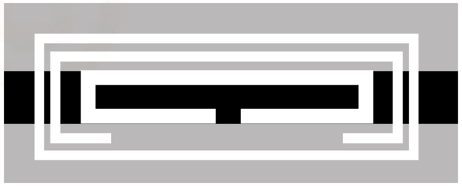


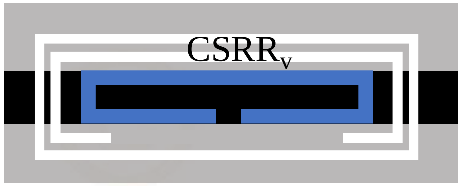
The Sensitive Part of the reader has **two operation frequencies**



3. Reader & Encoder

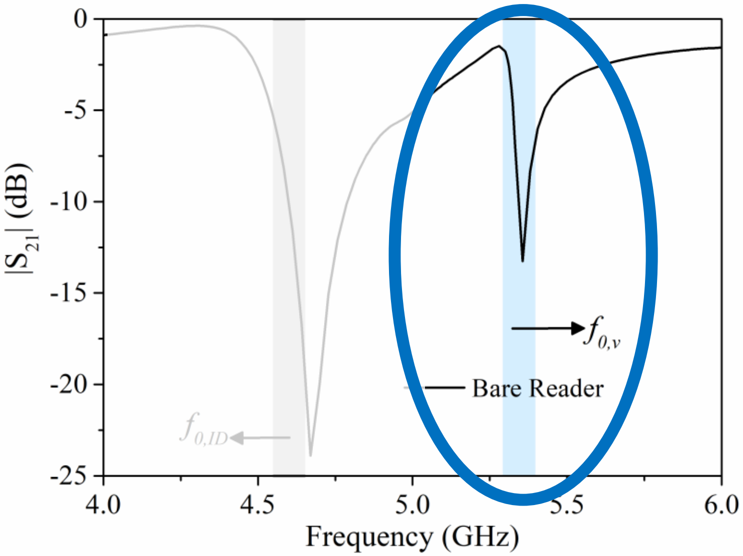
Sensitive Part





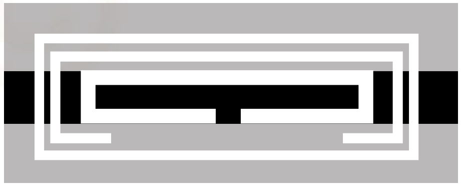
The **Inner** CSRR provides the higher resonant frequency at:

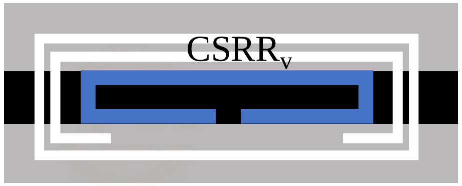
@ $f_{0,v}$ = 5.31 GHz

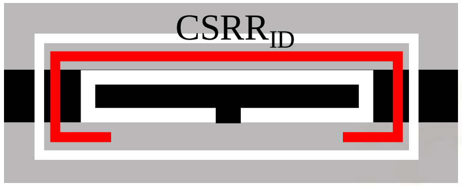


3. Reader & Encoder

Sensitive Part

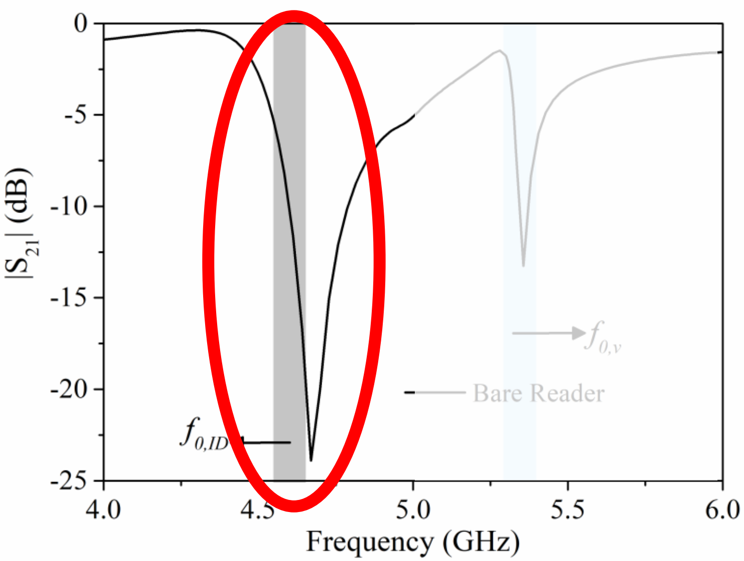






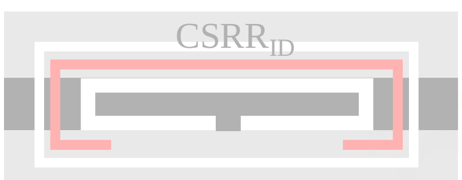
The **Outer** CSRR provides the lower resonant frequency at:

@ $\boldsymbol{f_{0,\,ID}}$ **= 4.63 GHz**

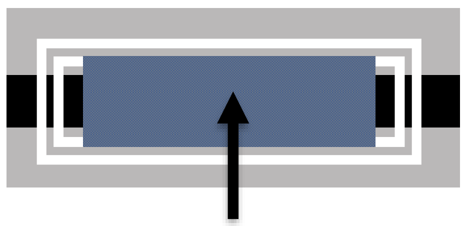


3. Reader & Encoder

Sensitive Part

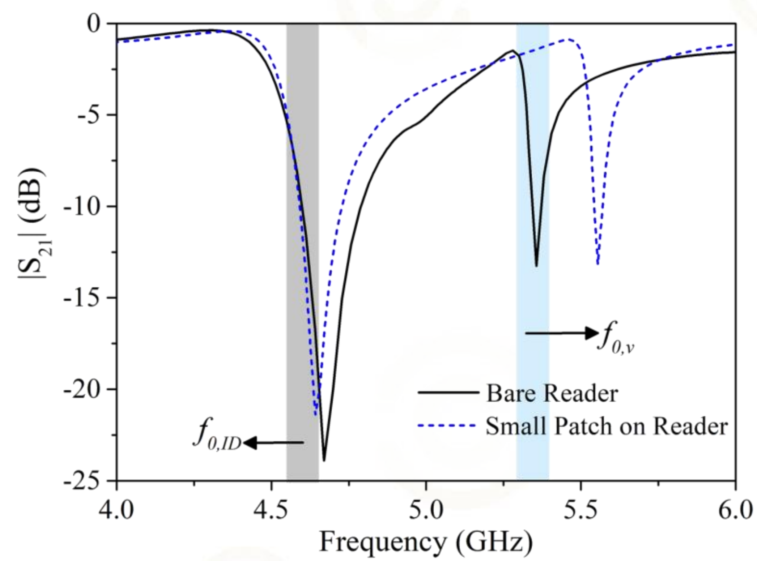


When a patch relies on top of the Sensitive Part



Narrow Patch

The **Narrow** Patch only has effect in the inner CSRR, resulting in a shift of the **higher** frequency

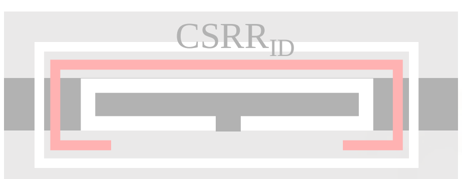


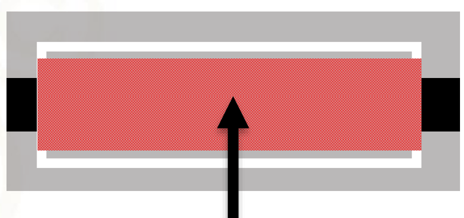
3. Reader & Encoder

Sensitive Part

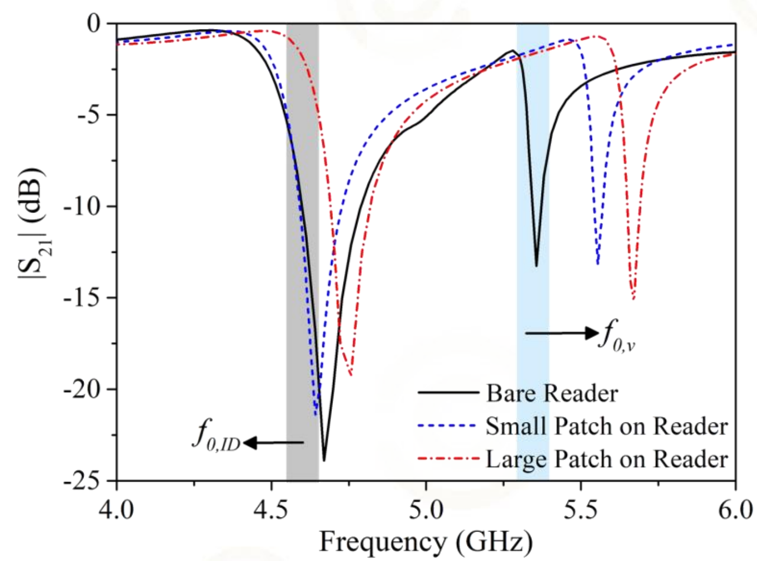
When a patch relies on top of the Sensitive Part

The **Wider** Patch has effect on both the inner and the outer CSRRs, resulting in a shift of the **lower** and the **higher** frequencies





Wider Patch

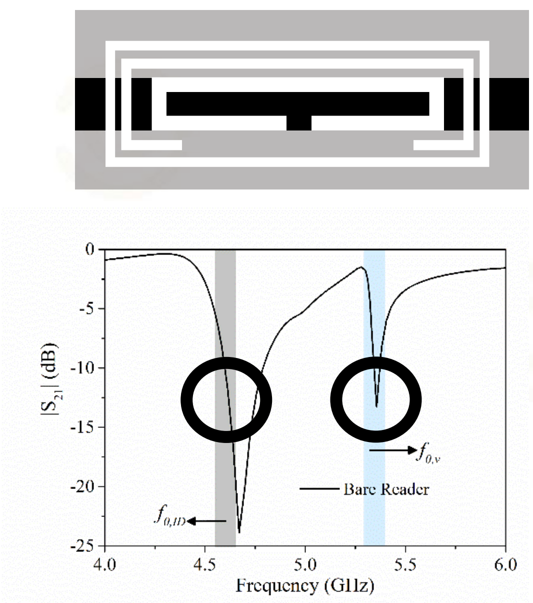


3. Reader & Encoder

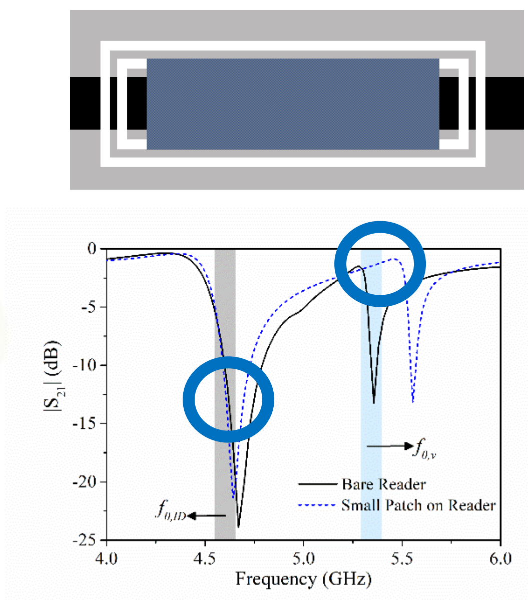
SUMMARY of the Binary States

	@ $f_{0,ID}$	@ $f_{0,v}$
Bare Reader	'0'	'0'
Narrow Patch	'0'	'1'
Wider Patch	'1'	'1'

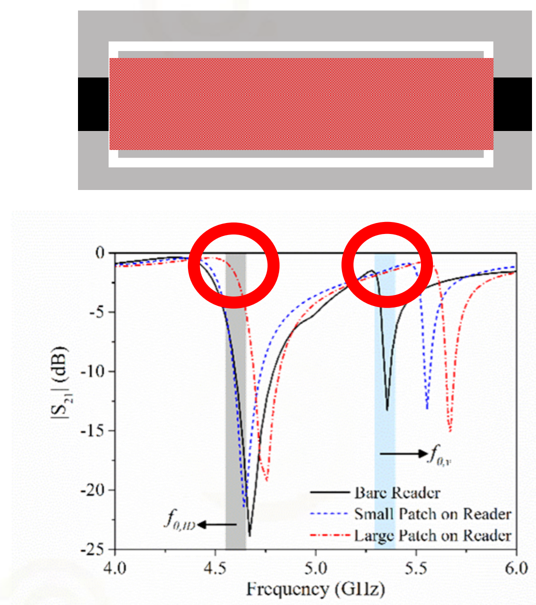
Bare Reader



Narrow Patch



Wider Patch



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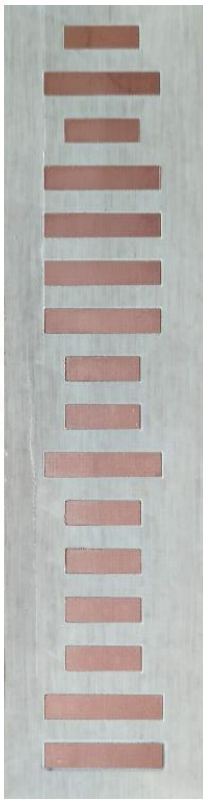
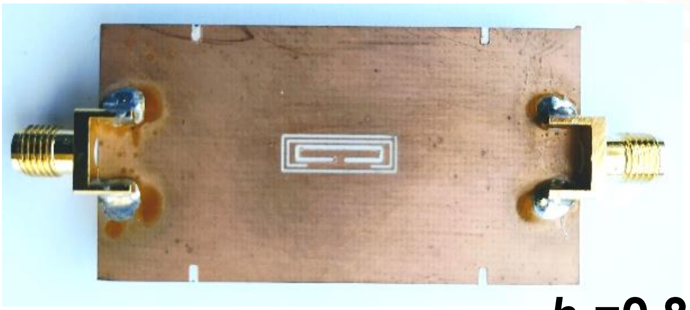
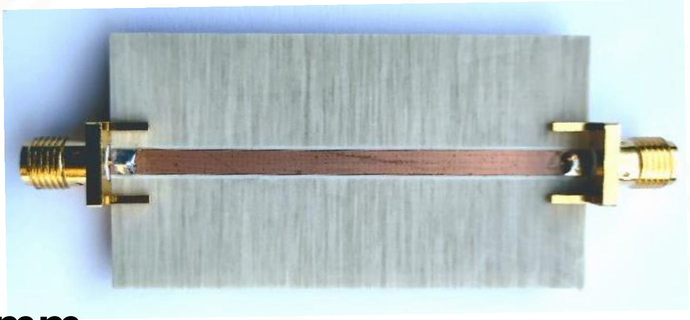
4. Fabrication & Measurement

Fabricated in ***Rogers RO4003C*** (ε_r = 3.38, tanδ = 0.0022) by means of a milling machine (*LPKF H100*)



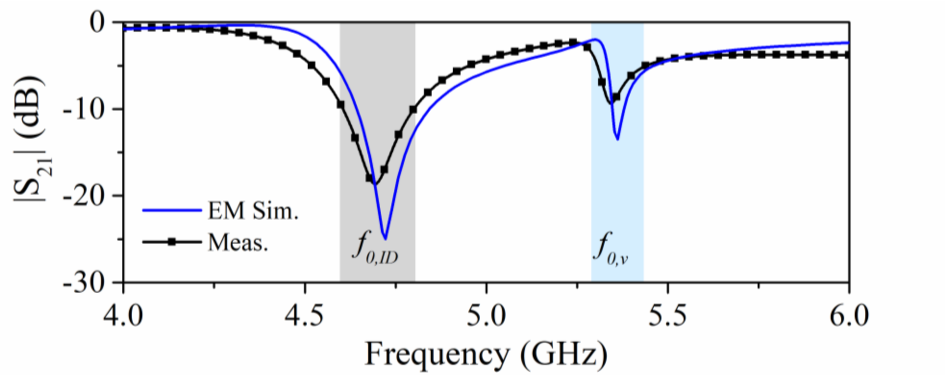
***h* =0.2 mm**





***h* =0.8 mm**

Electromagnetic Simulation and measurement of the sensitive part of the reader (bare reader)

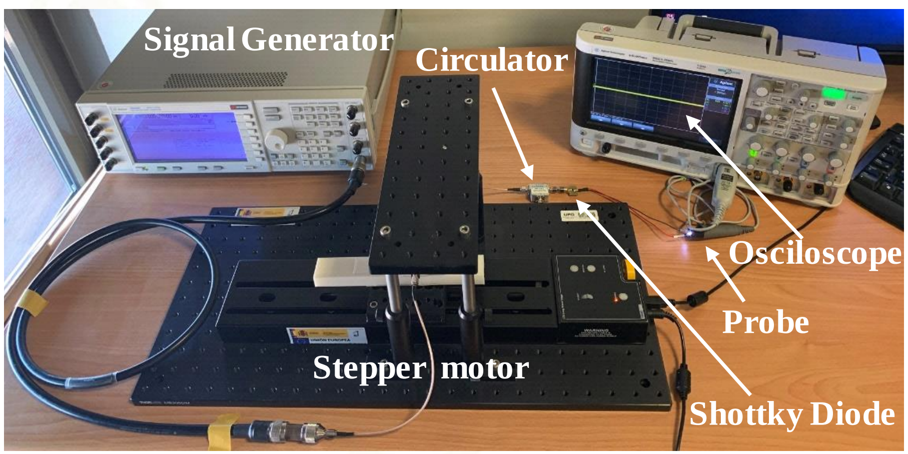


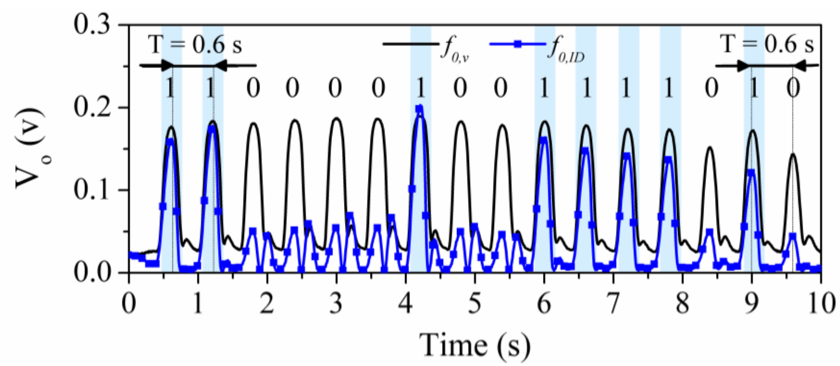
4. Fabrication & Measurement

The measurements were carried out **sequentially**, firstly generating the harmonic signal @ $f_{0,v}$ and later the harmonic signal @$f_{0,ID}$.

Finally, the results were jointly **processed**.

The **black peaks** allow us to determine the encoder **velocity**, whereas the **blue peaks** are the **identification** (Bruijn sequence)

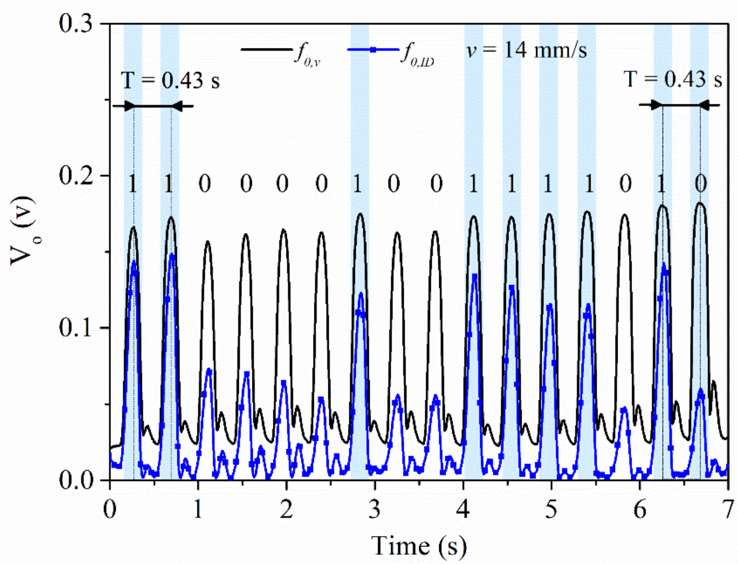


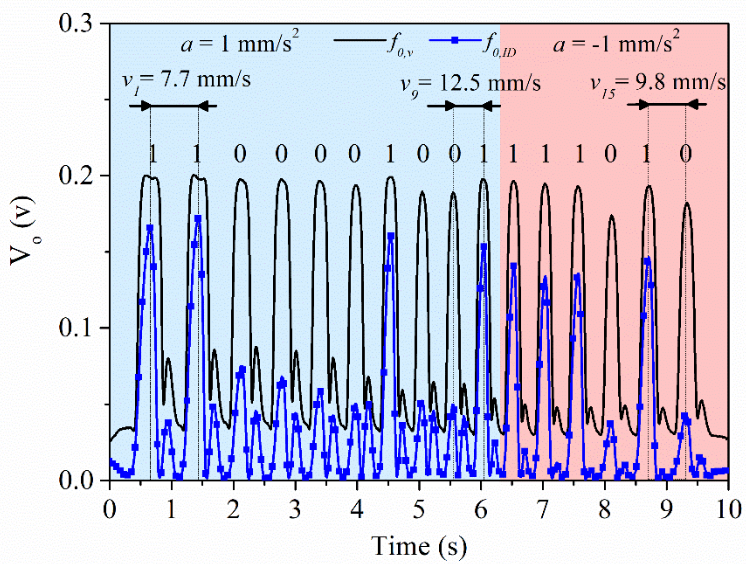


4. Fabrication & Measurement

The functionality of the system was tested by increasing the encoder **velocity** up to **14 mm/s**.

The encoder was also **accelerated** at **1mm/s²**, and in the middle of the reading, the encoder was **decelerated** at **-1mm/s²**.

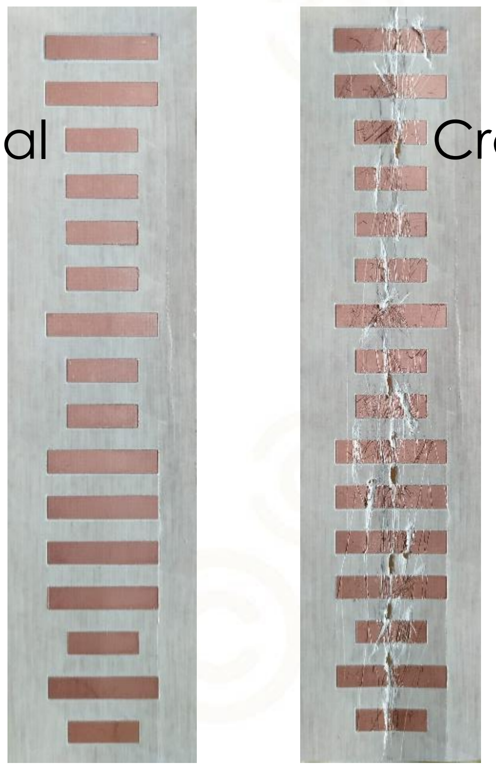




4. Fabrication & Measurement

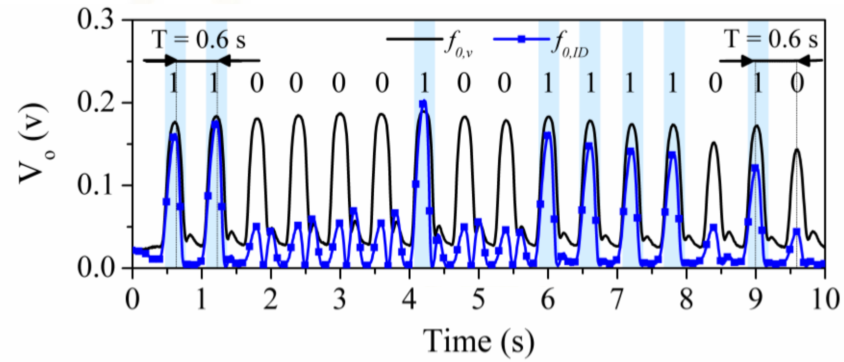
Finally, the encoder was **deliberately cracked** in order to test the robustness against **wearing or / and friction**.

Original

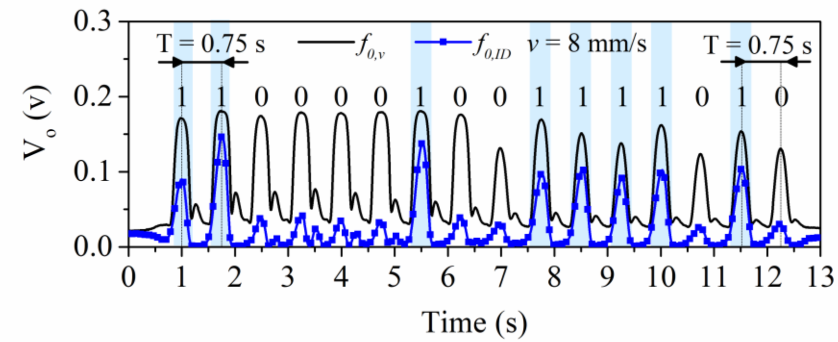


Cracked

Encoder **before** being cracked



Encoder **after** being cracked



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5. Conclusion & Future Work

- An approach for an **electromagnetic encoder** useful for motion applications, and based on the **Near-Field Chipless RFID approach**, has been proposed.

- The **Reader** consists on a microstrip line loaded with a pair of complementary split ring resonators (**CSRRs**). The **smaller CSRR** is devoted to determinate the **encoder velocity**, whereas the **longer CSRR** is used to infer the **ID code**.

- **Encoders** are based on a single chain of **rectangular patches,** and the **size** of the patch determines the binary state of **the ID**..

- **Experimental validation** was carried out by reading a **16-bits encoder** by testing different **velocities** and **accelerations**, as well as by cracking the encoder.

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for your attention

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