The counteractive effect of the sensor housing on unit sensitivity across a series of dynamic temperature profiles

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The advantages of wireless sensing implemented on the cold chain of fresh products

- Food chains are highly distributed, heterogeneous, and globalized with extremely diverse requirements => scenario based analysis

- The economic impact of product losses is referred
  - 10% in Europe (6-7% in retailers)
  - 15% in USA
  - while reaching 30% in developing countries (mostly to the lack of temperature control). *(Pang et al., 2011)*

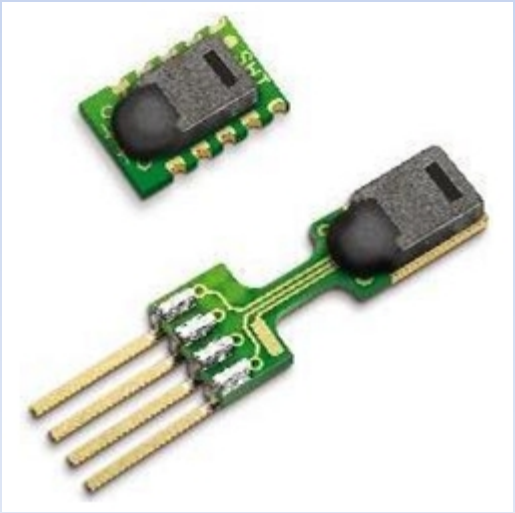
Being validated and used for cold chain monitoring and tracking

- Fruit chambers and refrigerated trucks during international transportation (*Ruiz-Garcia et al., 2008; Ruiz-Garcia et al., 2010).*
- The fresh fish logistic chain (*Hayes et al., 2005; Abad et al., 2009).*
- RFID semi-passive tags for monitoring cold chain in refrigerated trucks (*Jedermann et al., 2009*)
- Temperature tracking for pineapples from Costa Rica to the USA (*Amador et al., 2009*).

Key features for dynamic response

- Sensor housing or the Penelope-like strategy

- Sensor installation or the side effect of electronics



Premises and objective

- Up to date there is no scientific information available on the dynamic behavior of WSN and RFID as related to sensor housing or mounting on the base electronics.

- The aim to this study is therefore to assess the dynamic behavior of the sensors as crucial for a proper characterization of history reconstruction.

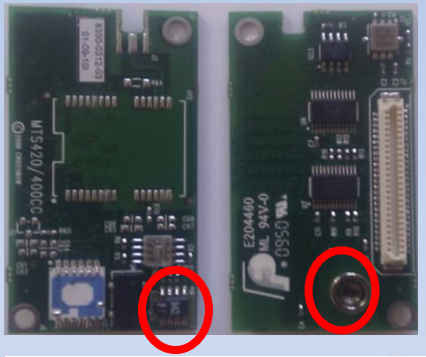
LABORATORIO DE PROPIEDADES FISICAS Y TECNOLOGIAS AVANZADAS EN AGROALIMENTACION

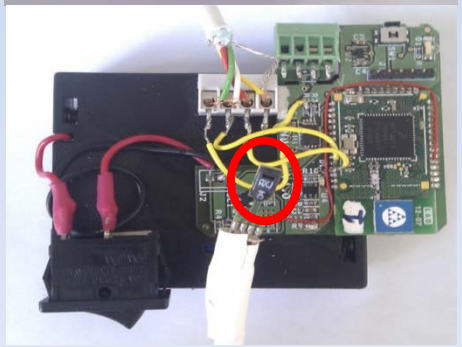
POLITÉCNICA

Materials and methods

- RFID: Turbotag™

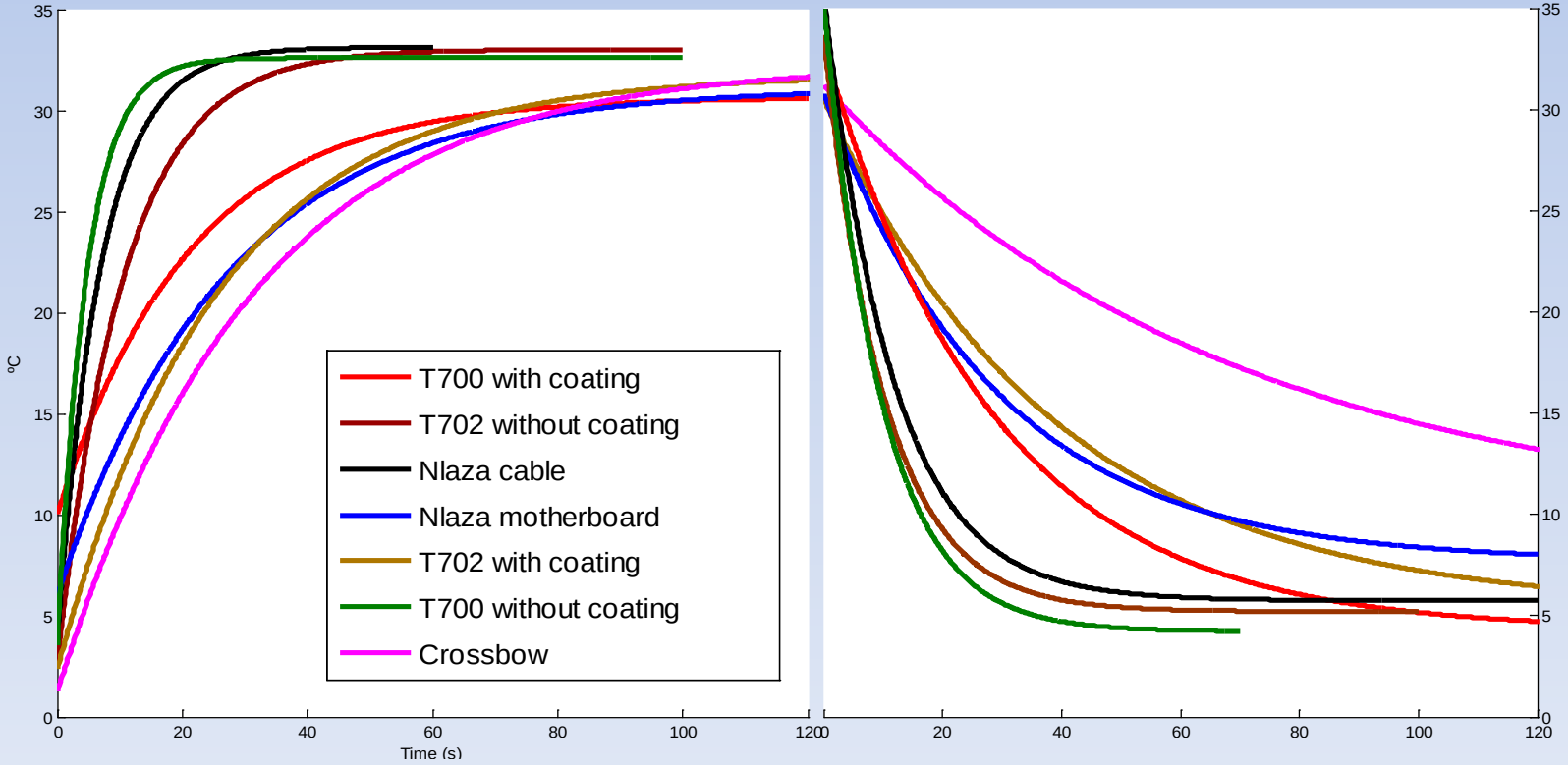
- Zigbee: SENSIRION
- Nlaza, Crossbow



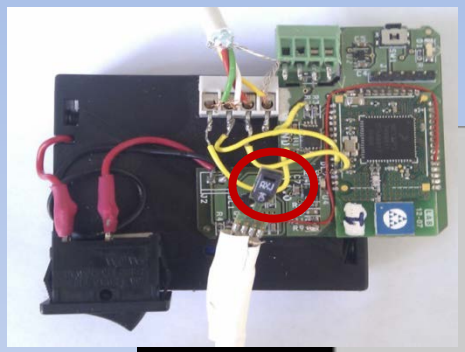


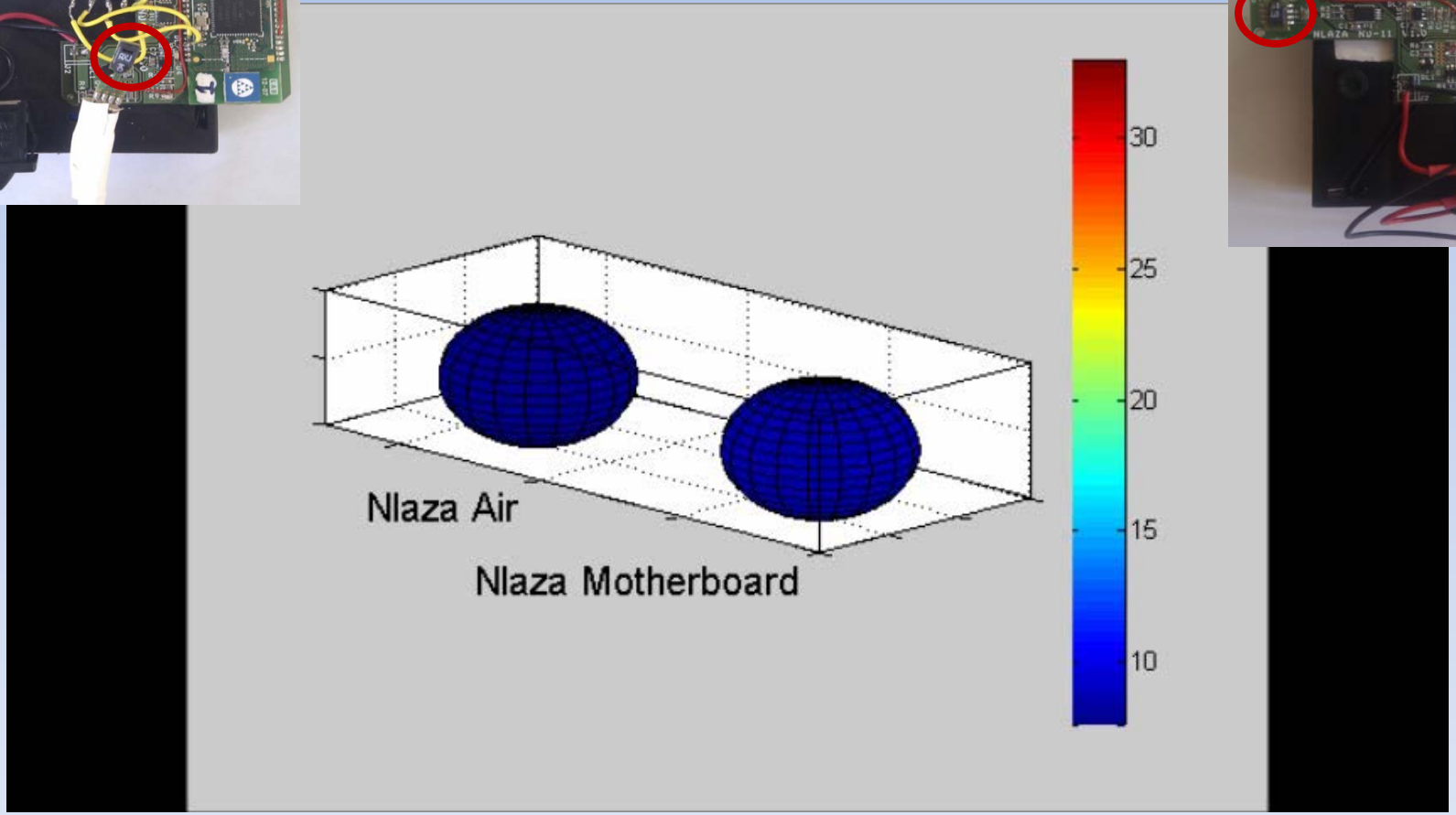
Sensor response as a first order system when using a step-shaped temperature step

$$y_{up} = k * x * (1 - e^{-t/\tau}) \; ; \; y_{dw} = k * x * e^{-t/\tau}$$

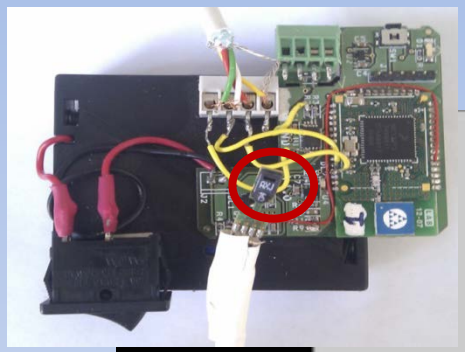


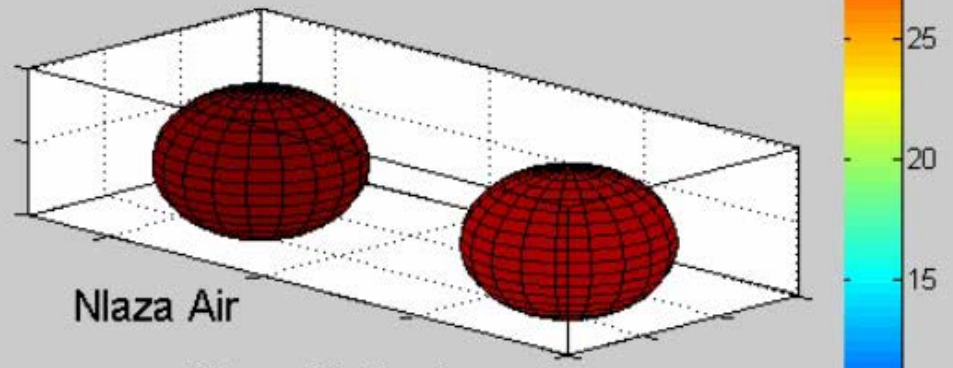
Upward shape

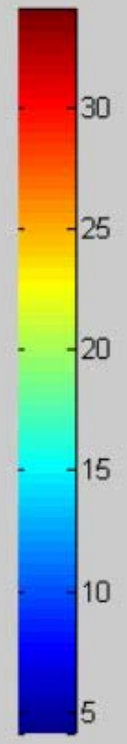




Downward shape



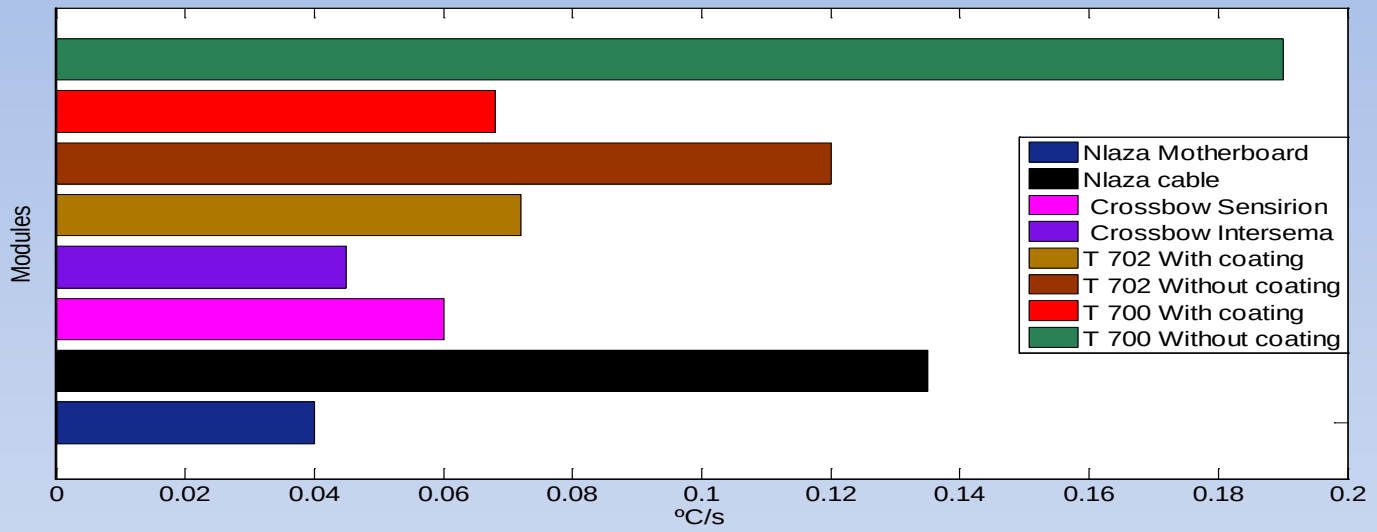




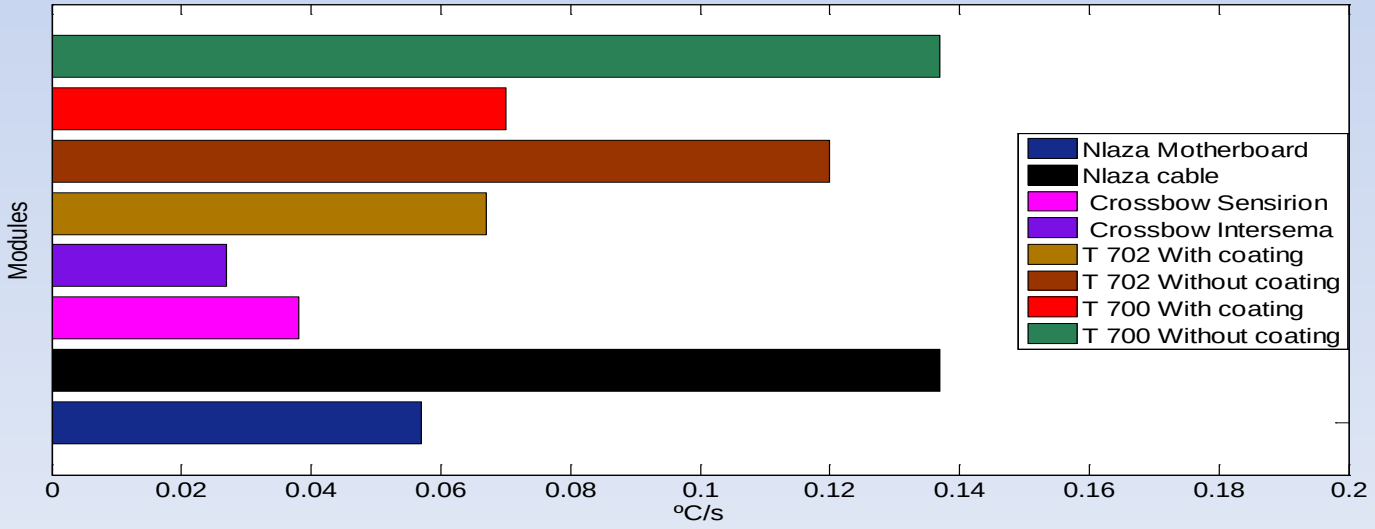
Time response (τ) and r^2

		Upward shape		Downward shape	
Device	Status	τ (s)	r^2	τ(s)	r^2
T700	With coating	107.2±0.3	0.99	115.0±0.3	0.99
	Without coating	20.9±0.3	0.99	45.8±0.6	0.98
T702-B	With coating	131.2±0.3	0.99	156.8±0.3	0.99
	Without coating	53.8±0.6	0.98	57.6±0.9	0.97
Nlaza	Motherboard	126.4±0.3	0.99	184.0±0.3	0.99
	air	42.8±0.3	0.99	58.4±0.3	0.99
IRIS Sensirion	Motherboard	144.4±1.2	0.96	254.0±0.6	0.98
IRIS Intersema	Motherboard	264.1±1.2	0.96	292.9±0.6	0.98

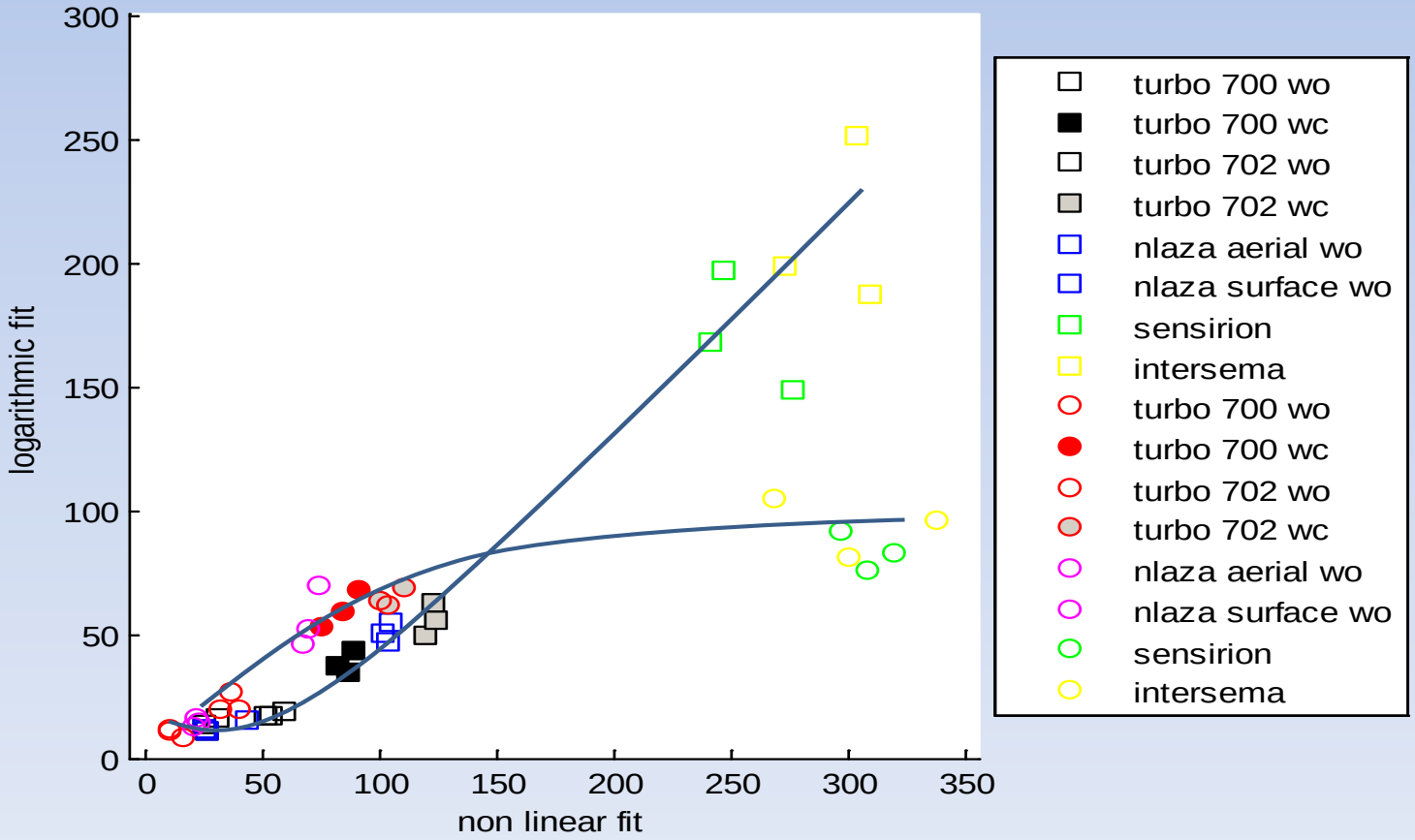
Rise Response (5 ºC→35 ºC)

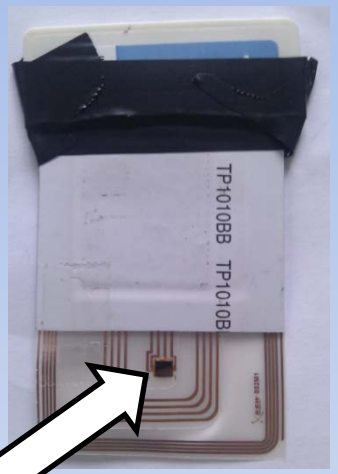


Fall Response (35 ºC→5 ºC)



Non-linear fit (NLF) and traditional logarithmic approach (TLA)

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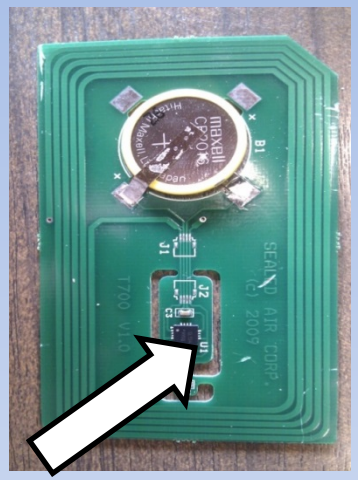
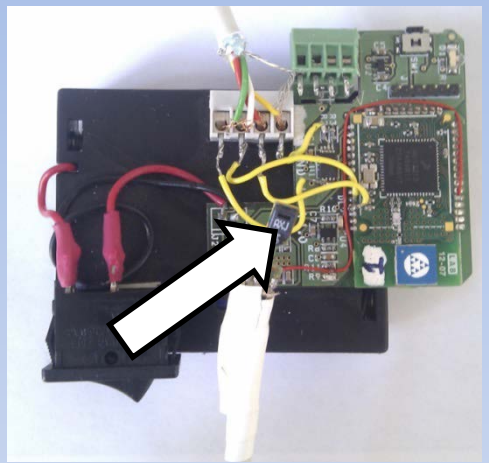
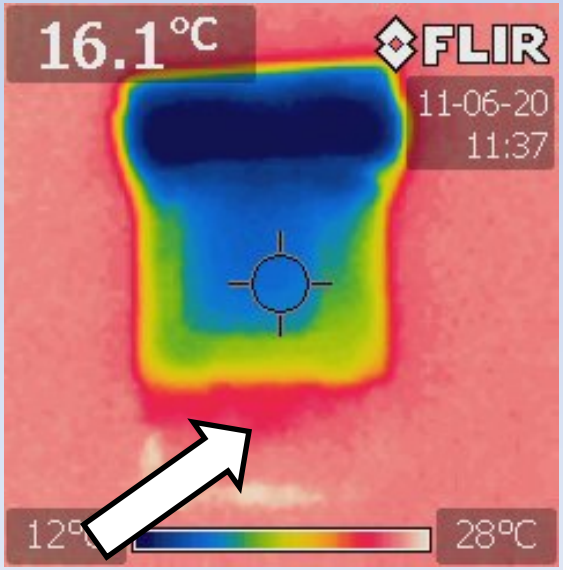
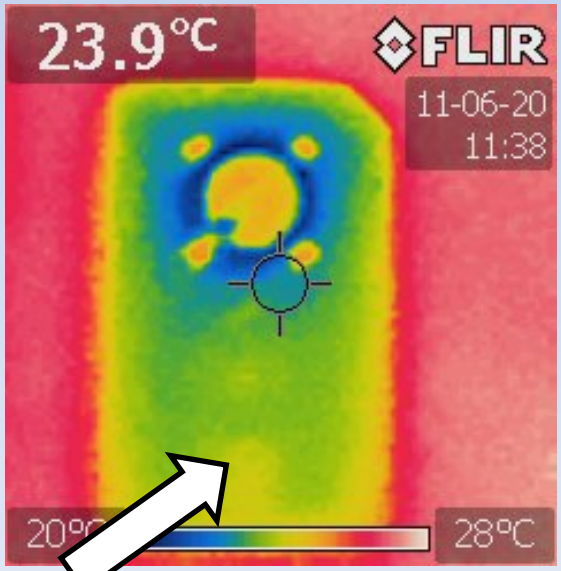
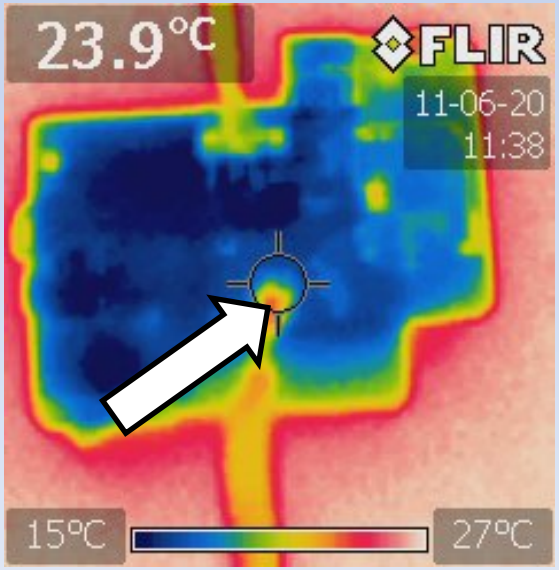

maxell
SEAL AIR CORP.




16.1°C
FLIR
11-06-20
11:37
12°C
28°C


23.9°C
FLIR
11-06-20
11:38
20°C
28°C


23.9°C
FLIR
11-06-20
11:38
15°C
27°C

Conclusion 1/2

- Sensor accuracy is being negatively influenced by :
  - The housing.
  - The heat released by the node electronics itself;

  Its characterization is basic to allow monitoring of high rate temperature changes and to certify the cold chain.

- Fastest response time 20s, temperature cycles of higher frequency cannot be addressed with available wireless technologies.

- Slowest response (264.1 s) corresponds to surface-mounted sensors which refers the need of a dedicated design.

Conclusion 2/2

- Sensor located in a insolated position, product extremely sensitive to high temperature → the reaction rate is not good enough and it is limiting the capability of adaptation of the devices.

- This study can serve as a starting point to localization optimization of the devices or temperature estimation experiments.

Acknowledgements

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Thanks for your attention

Questions???