# Time reversal: a flexible approach for identifying and measuring surface acoustic wave delay lines acting as wireless, passive sensors

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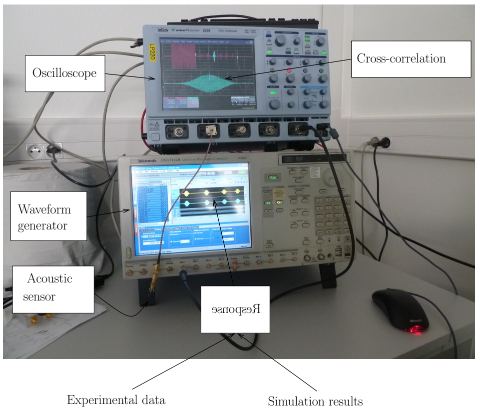
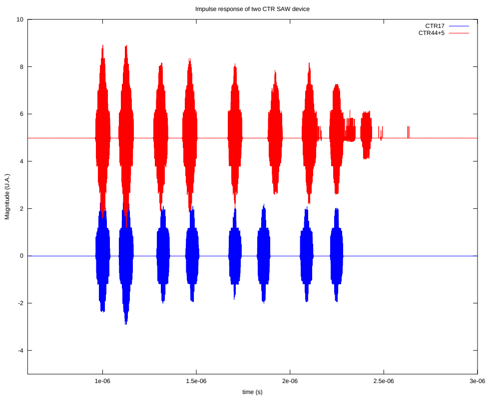
**Context:** surface acoustic wave (**SAW**) devices used as **passive sensors** interrogated through a **wireless link**.
**Objective:** develop interrogation strategies compatible with **identification** and physical quantity **measurement** + **anti-collision**.

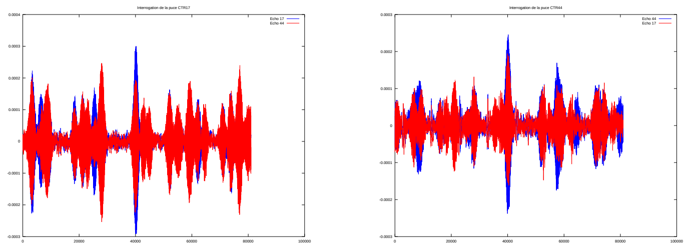



- Experimental setup: arbitrary waveform generator used to emit the time-reversed inverse Fourier transform of the spectra (**measured** or **simulated**).
- Demonstration at 2450 and 868 MHz
- Left: experimental setup. Right: impulse response of two 2450 MHz delay lines used for this demonstration.



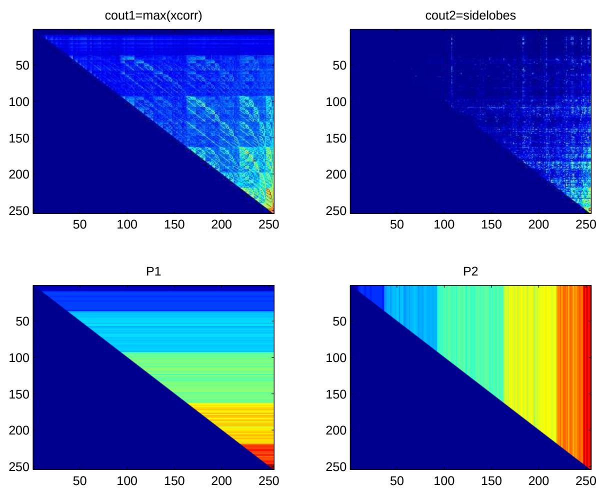

## Time-reversal for SAW delay line identification

- Acoustic delay lines act as **correlators**: if incoming signal matches transfer function, a compressed cross-correlation pulse is returned
- Assuming orthogonal transfer functions, a single delay line should return a pulse to a probe function.



Time-dependent returned signal when probing a delay line with the time-reversed transfer function (max) and that of another device (1 bit difference).

**Issue: how to select orthogonal codes ?**
Simulation tools appropriate to model *all possible combinations* of open and shorted mirrors ⇒ case of a 8-mirror delay line

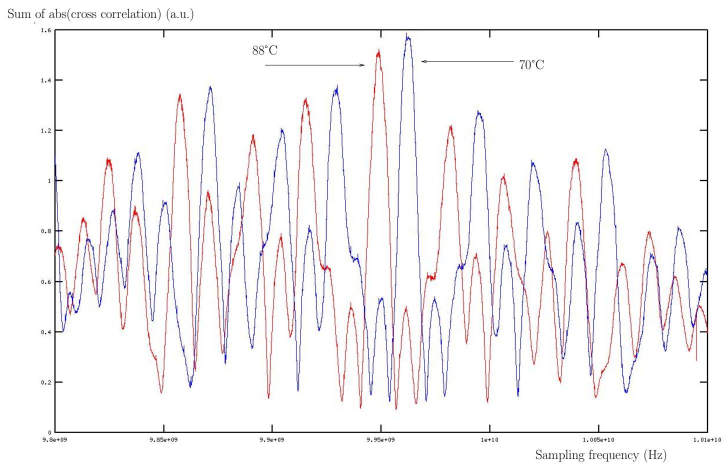



Cost function:

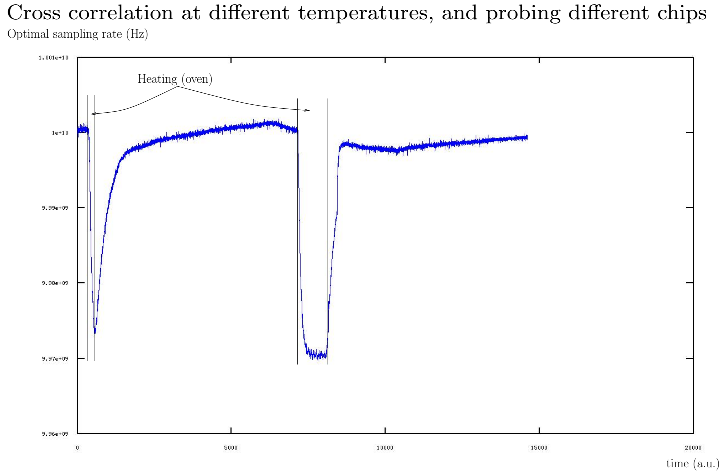
1. maximize returned power (maximum number of mirrors)
2. maximize auto-correlation function
3. minimize cross-correlation with other chips
4. minimize sidelobes

## Time-reversal for measurement (application to temperature)

- Physical quantity variation → velocity variation → time stretching
- Sweep sampling clock of arbitrary waveform generator
- → track sampling frequency for which cross-correlation is maximized,
- "hardware" (acoustic) cross correlation ⇒ fast measurement (no digital signal processing)




Cross correlation at different temperatures, and probing different chips




Tracking sampling rate maximizing cross-correlation as sensor is heated.

**Conclusion:** time-reversal is used for identifying a single device within a population (identification & anti-collision) and measure the physical quantity changing the acoustic velocity (temperature)
**Perspectives:** improve orthogonality & conversion of the laboratory experiment to an embedded interrogation electronics