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MicroLap: Microwave Lap-Timing from HHF

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Motivation

- Solution for timing purposes in motorsport applications
- Highly flexible
- Highly accurate
- Cost effective

PC-controlled

Basestation
2.45GHz-
receiver

Highlights of MicroLap

- Full developed and tested lap-timing system
- Highly flexible, best for
  - Race tracks (single- and multi-point-measurements)
  - Off-road, on-water (long distance up to 150m), free-space
- Highly accurate
  - Optimized antennas
- Cost effective in
  - Production
  - Installation

Development History

- Start of diploma thesis autumn 2006
- Proof-of-concept spring 2007
- Funding through EU / state scholarship in autumn 2007
- Fully functional prototype system with 40 transponders in winter 2007/2008
- Second generation system in spring 2008
- Antenna for long distance applications in 2009

Receiver with monitor to show the actual results

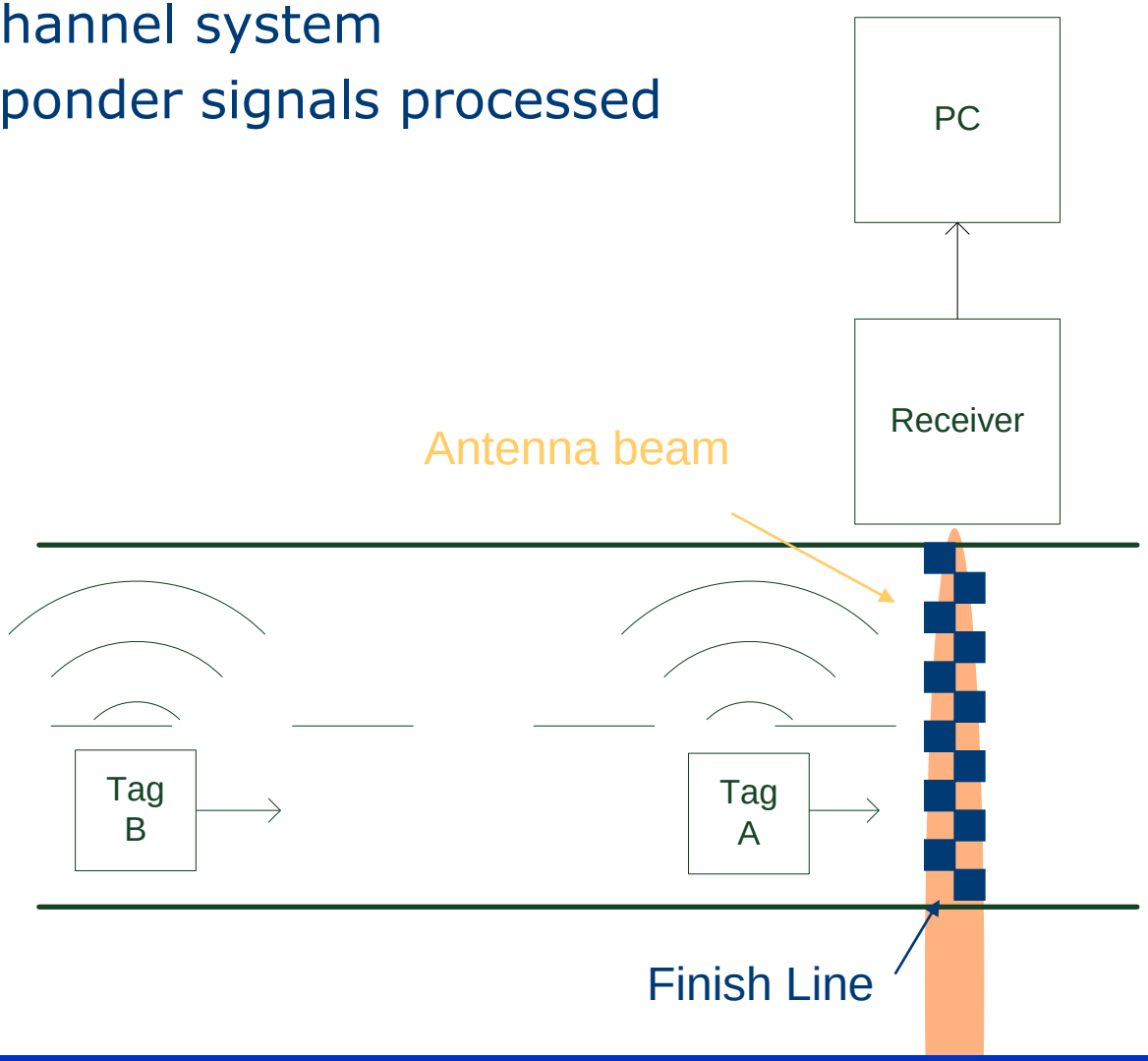
Development Side-Steps

- Energy saving concepts with separate RF-activation signals have been developed, but postponed
- Solutions with user-readable lap-time displays have been developed, but canceled for greater battery life and simplicity of design
- The final transponder layout is the 28th version, but less complex in design than many of its predecessors

Transponder with display

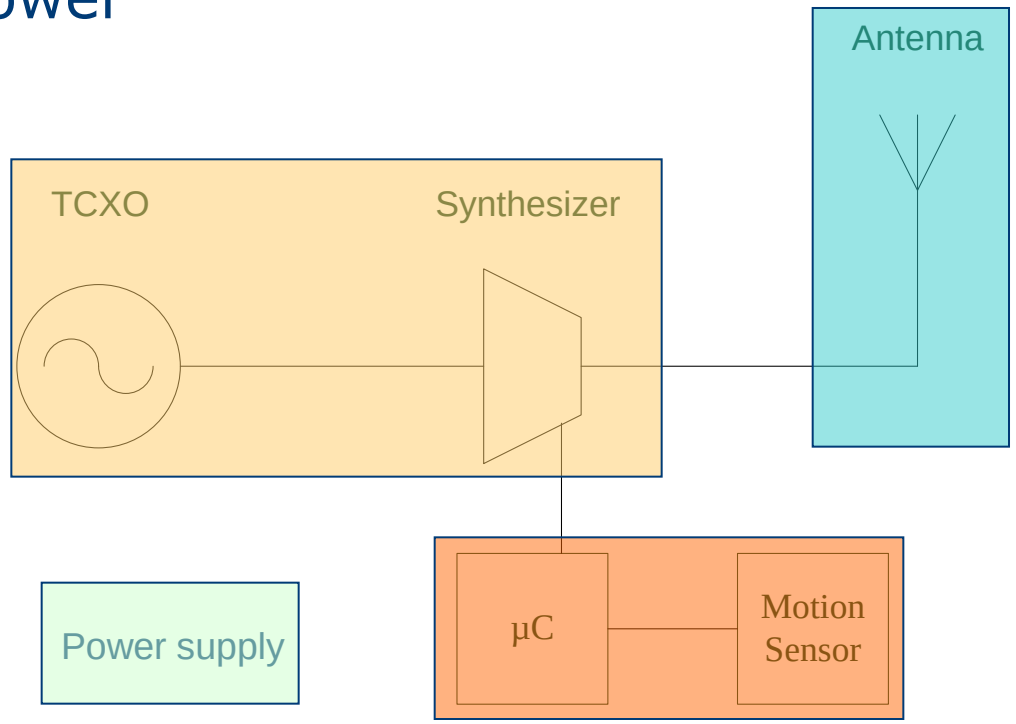
Concept of MicroLap

- 2.45 GHz multi-channel system
- Up to 2000 transponder signals processed simultaneously



Concept of MicroLap / Transponder

- Individual frequency channel
- 62.5 kHz channel spacing
- 10 dBm / 10 mW RF power

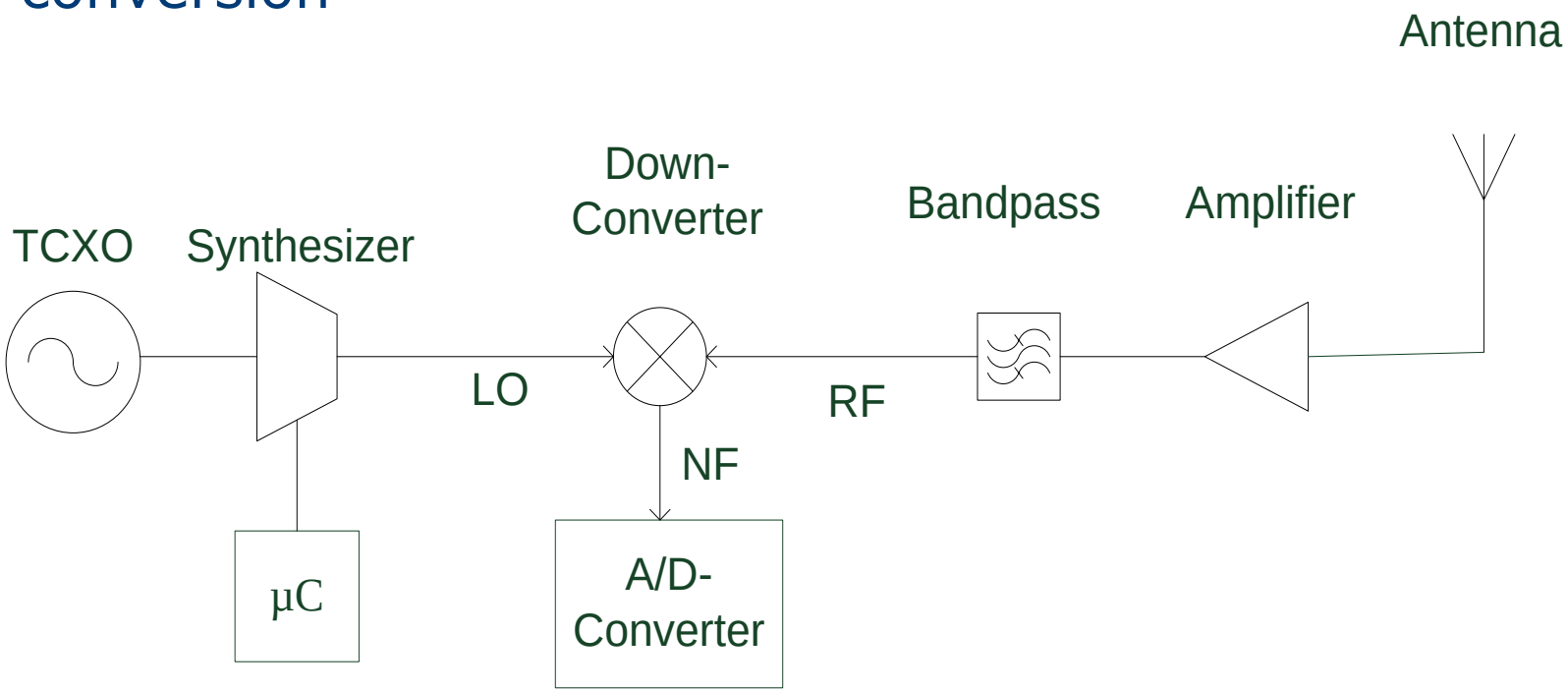


Concept of MicroLap / Transponder

- Current dimensions ~ 80x45x17 mm^3
- Main dimension constraints: Antenna and battery
- Current weight: ~ 90 grams with partial casting compound

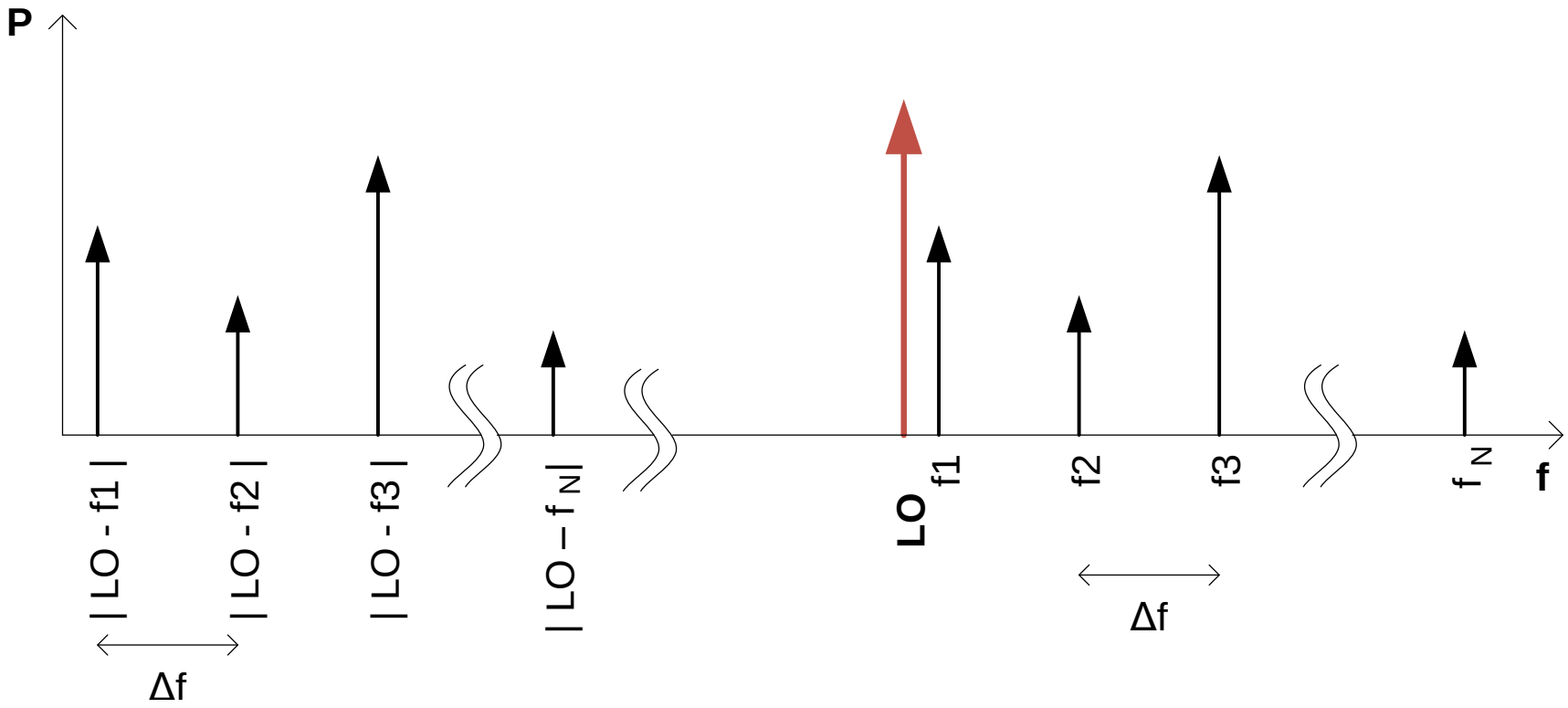
Concept of MicroLap / Receiver

- Low noise layout
- Highly optimized antennas
- NF bandwidth saving for efficient A/D conversion



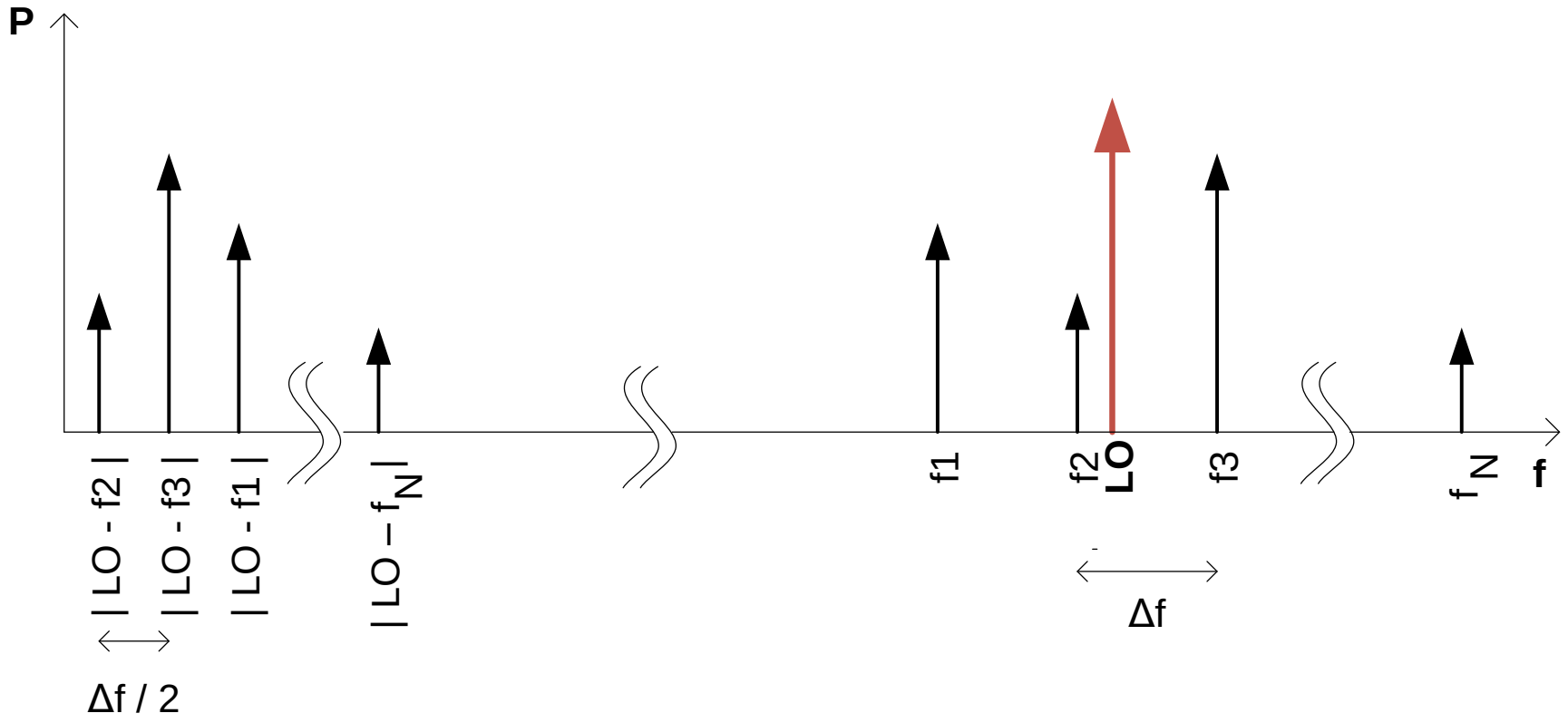
Single Sideband Converter

Frequency spectrum to explain functionality



Reduction of NF Bandwidth

Frequency spectrum to explain functionality



Concept of MicroLap / Antennas

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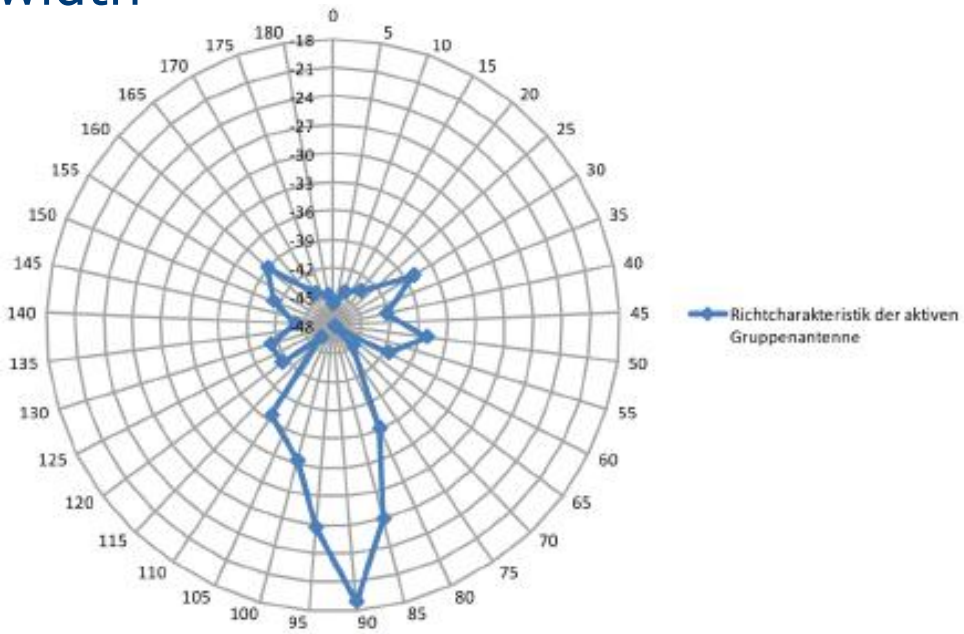
Compact antenna for short range applications

- Narrow antenna lobe (beam) increases range and precision
- Several studies led to development of a quadruple-patch group layout
- No dielectric losses for high efficiency
- Compact layout
- 14 dBi, circular polarisation, 35° horizontal beam width

Concept of MicroLap / Antennas

Large antenna for long range applications

- Very narrow antenna lobe (beam) increases range and precision
- No dielectric losses for best efficiency
- 40 dBi, circular polarisation, 4° horizontal beam width

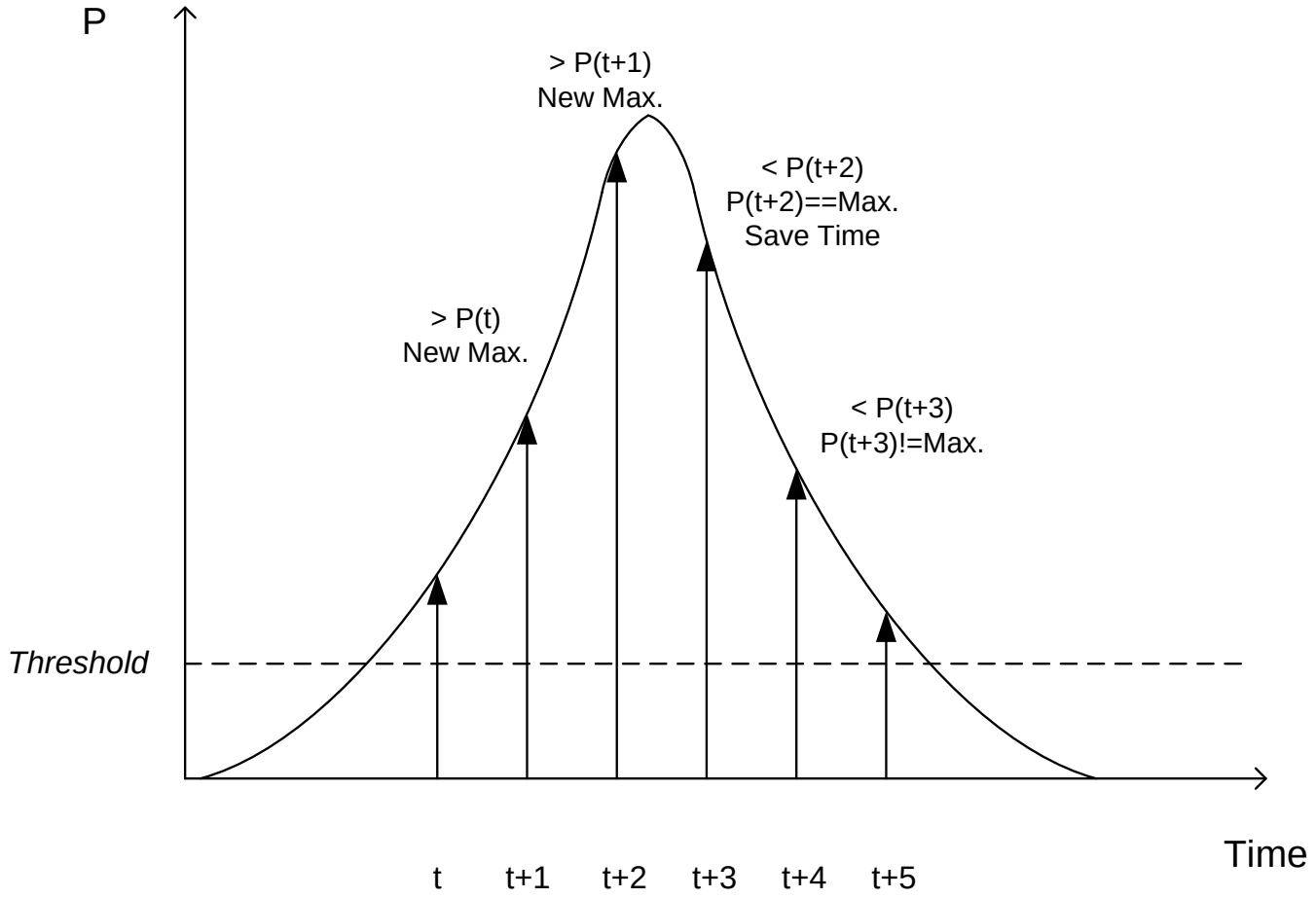


Concept of MicroLap
Signal Processing I

- A/D Conversion with specialized hardware in a standard PC (12 bit, 40 MS/sec)
- FFT limits timing accuracy in current layout

Concept of MicroLap Signal Processing II

- Acquisition of passing time with an optimal signal



Concept of MicroLap
Signal Processing III

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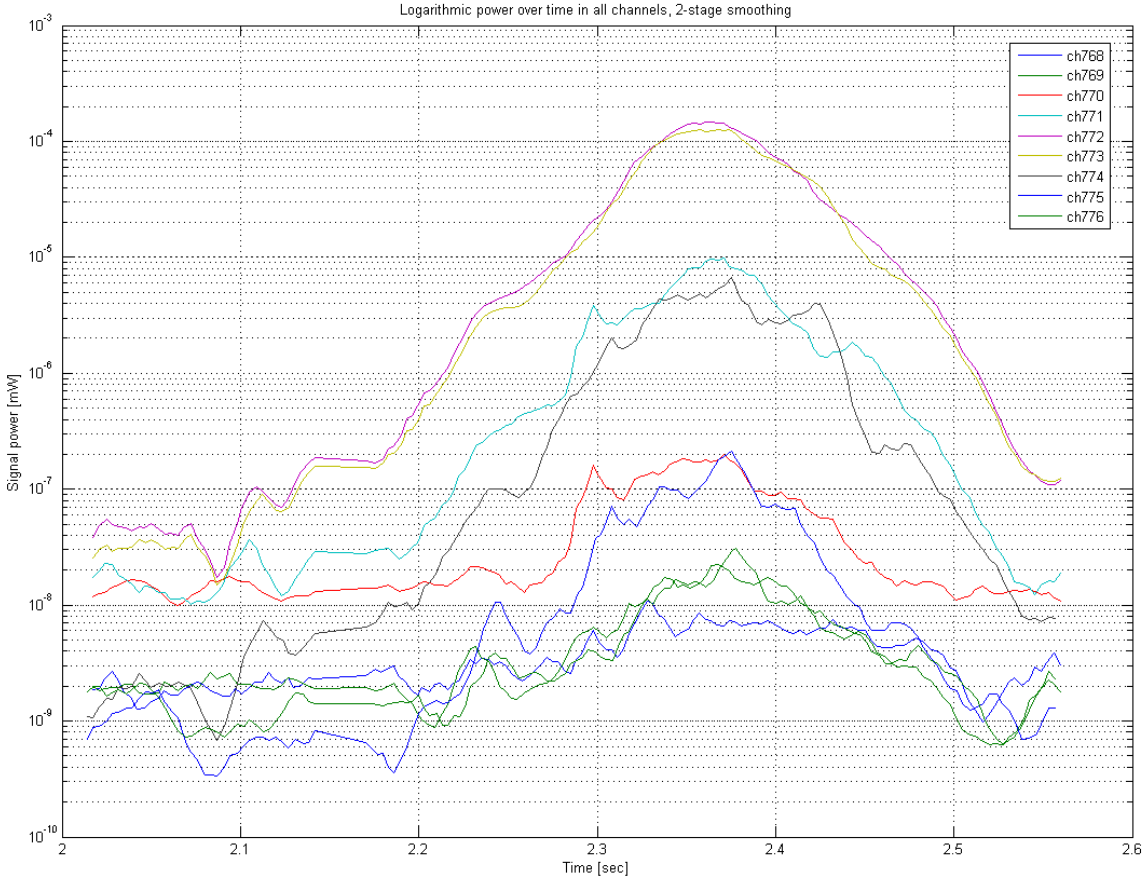
- Actual signal shape of a passing transponder



Concept of MicroLap
Signal Processing IV

- Transponder signal has to be monitored before and after it passes the finish line
- Threshold signal can be used to trigger external device, e.g. photoelectric barrier, before passing
- Signal shape can be used to enhance precision

MicroLap-test in Most

MicroLap Test Program

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A large number of tests were conducted:

- Motorcycle street events in Dijon, Most, Brünn (Brno) and Valencia
- Motocross training in Kleinhau near Aachen
- Test program included measurements of
  - precision (self-related and competitor solution)
  - range
  - reliability
  - immunity against RF disturbance
  - parallel measurement of multiple transponders
  - effects of shadowing by other motorcycles

MicroLap Test Results

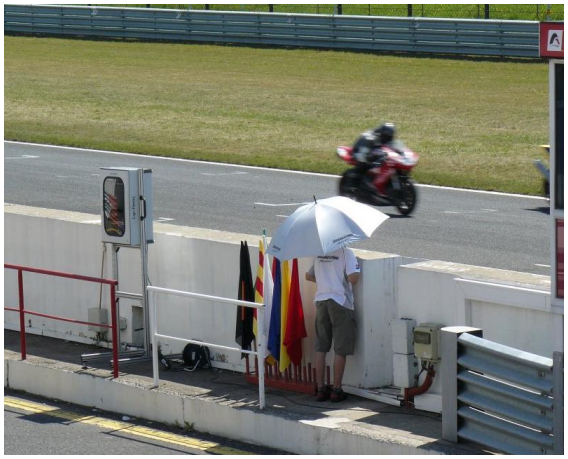
- System was tested on numerous occasions during street and motocross events

MicroLap Test Results

- Valid detection rate improved from 95% in 2007 to 100% during the last tests

MicroLap Test Results II

- Excerpt from simultaneous crossing test (12 transponders fitted to one motorcycle):
  - Standard deviation first passing: 5.97 ms
  - Standard deviation second passing: 4.32 ms
  - Standard deviation lap time: 4.98 ms
  - Absolute maximum deviation: 17 ms



MicroLap System Performance

- Up to 30 meters of detection range with short range antenna
- Timing accuracy limited to ~ 10 ms by FFT hardware
- Easily upgradable to multiple intermediate measurement points
- Up to 14 days of standby time

Manufacturing Costs

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Estimation of one system with 200 transponders:

- Transponder raw material (excluding battery) ~30 €
- Receiver station ~2500 €

- Additional requirements:
  - Charging device for single transponder ~10 €
  - Charging device for multiple transponder ~100 €

Development Costs

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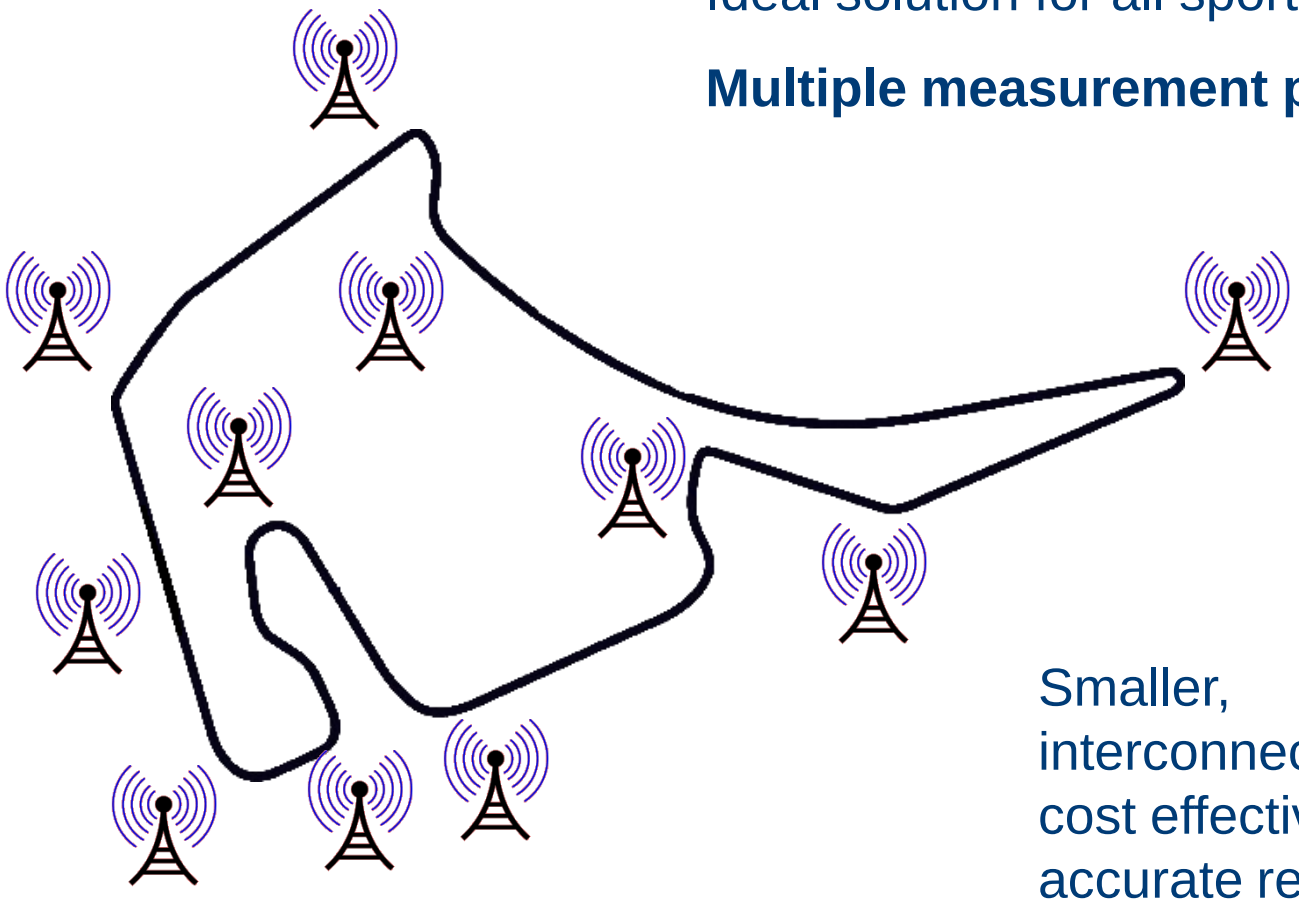
Costs of the past for one system with 60 transponders and two antennas:

2 engineering man years:	~100 t€
1 man year university personnel:	60 t€
0.5 man year software development:	25 t€
Hardware, material	15 t€
Production costs	15 t€
Testing costs	10 t€
	========
	225 t€

Future Prospects



Ideal solution for all sport areas:

Multiple measurement points (wireless)

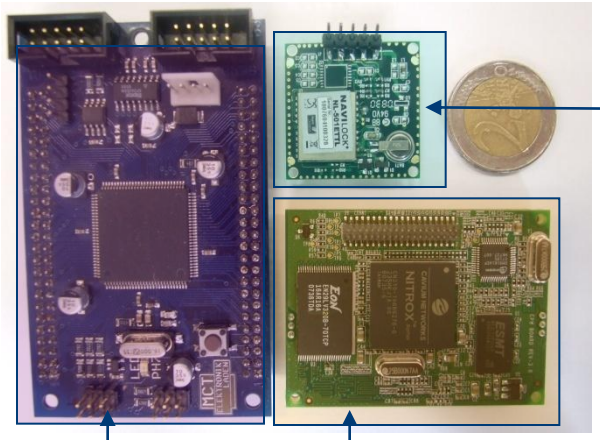
Smaller, interconnected, more cost effective, more accurate receiver stations

Future Prospects

- New receiver implementation
- Quicker FFT (~100 µs)
- Higher analog bandwidth (65 MS/s)
- Higher digital resolution (14 bit)
- Manufacturing costs cut in half

Tests at different positions

Future Prospects



GPS

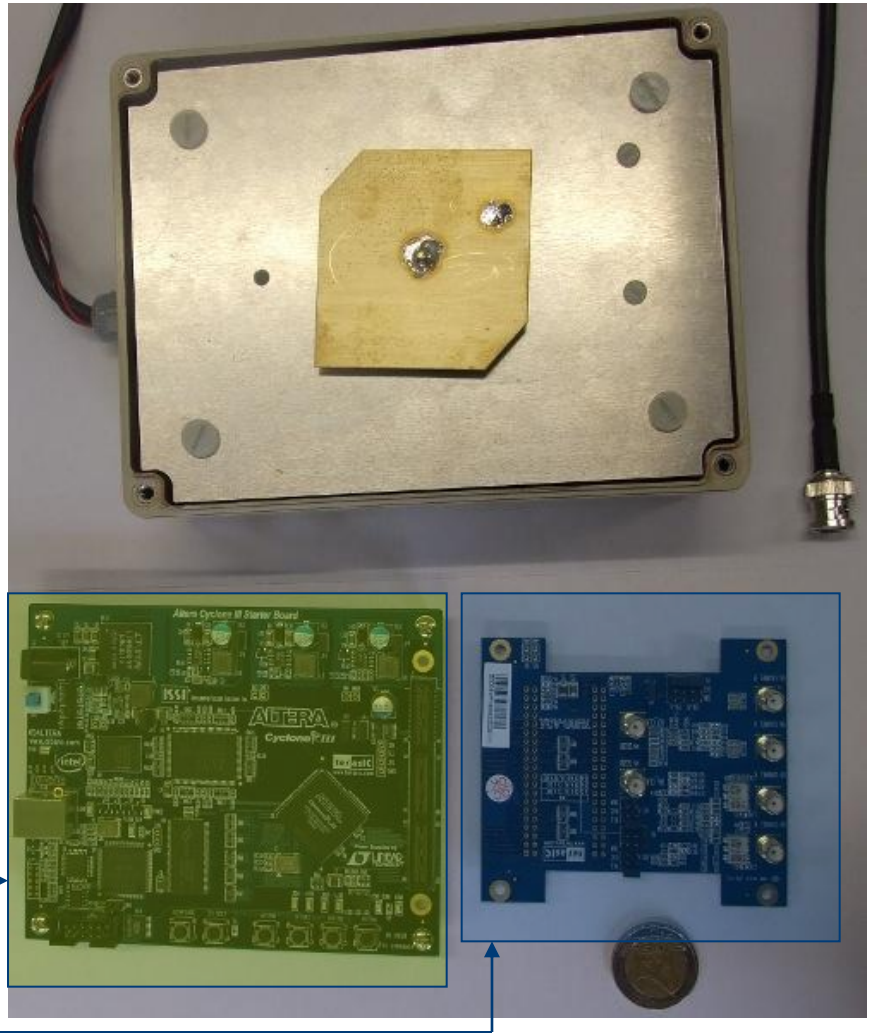
W-LAN

Microcontroller (HC12)

Pre-development of low-cost receiver station

FPGA – Board (FFT)

ADC - Board



Our Price of MicroLap

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We offer MicroLap for 68.000€ including:

- All rights of the system
- One full working and tested MicroLap system including
  - short and long range antenna
  - receiver station in a waterproof case for display and plot of actual results
  - over 60 transponder
  - specials like charging stations and transponder with Lap-timing-display
  - a lot of electronic components
- Training and documentation for production

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