

RUHR-UNIVERSITÄT BOCHUM

# Analog Design Contest 2014

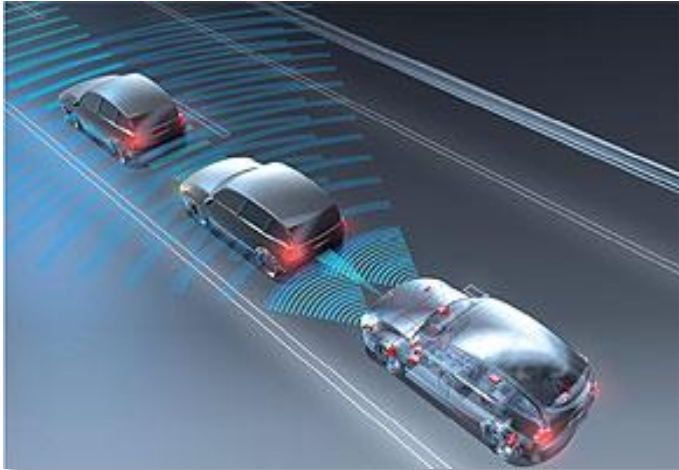
## Advanced High Resolution Radar Systems for Future Industrial and Medical Applications

Team: V. Kloubert, B. Janßen, A. Küter, S. Küppers, T. Jaeschke  
Supervisor: N. Pohl



TI university program

# Introduction – Radar Fundamentals



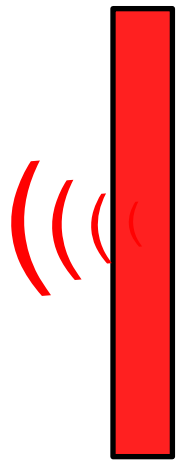
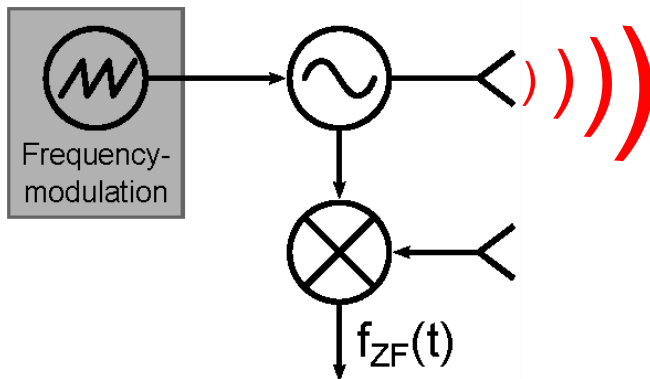
Source: ATZelektronik worldwide Edition: 2009-06



Source: Bosch

- Advances in Technology  
→ Radar for Consumer Markets  
→ E.g. Automotive Sensors
- FMCW Principle  
→ TX: Frequency Ramps  
→ RX: Time Delayed Signal

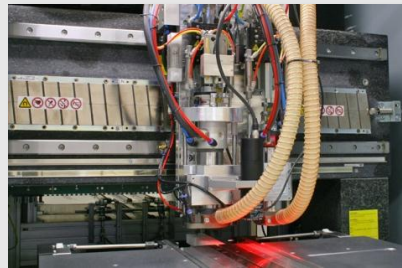
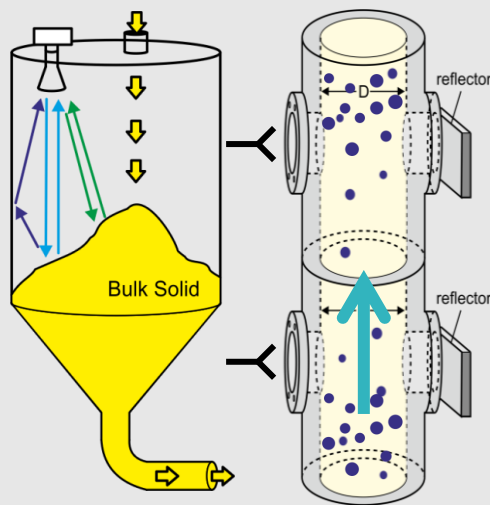
Time Delay → Distance 



# Overview – Radar Applications

## Industrial

Tank Level Probing | Flow Metering  
Machine Monitoring | Calibration



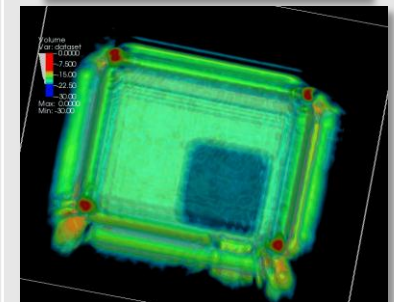
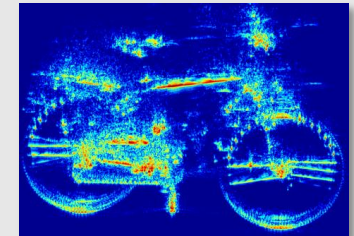
## Medical

Vital Sign Monitor  
Vision Sensor



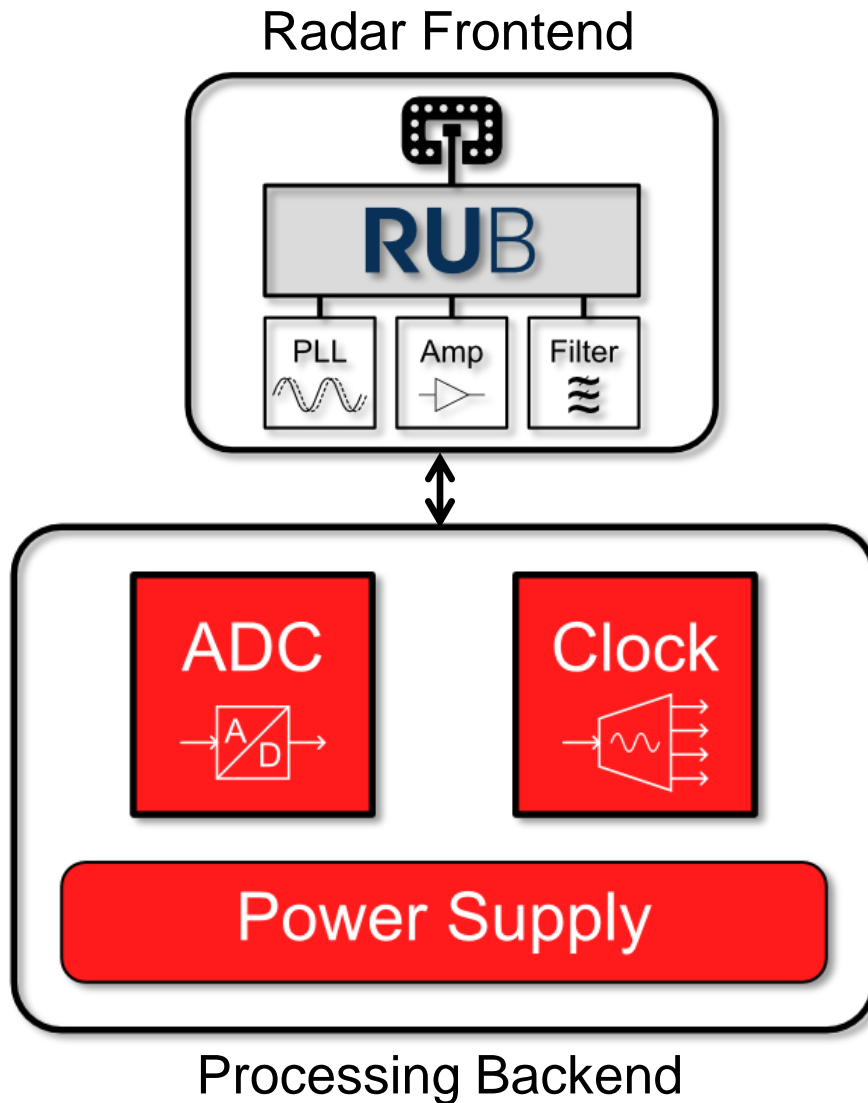
## Imaging

Quality Control  
Surveillance



- High Precision Sensing of:
  - Distance
  - Velocity
  - Dielectric Material Properties

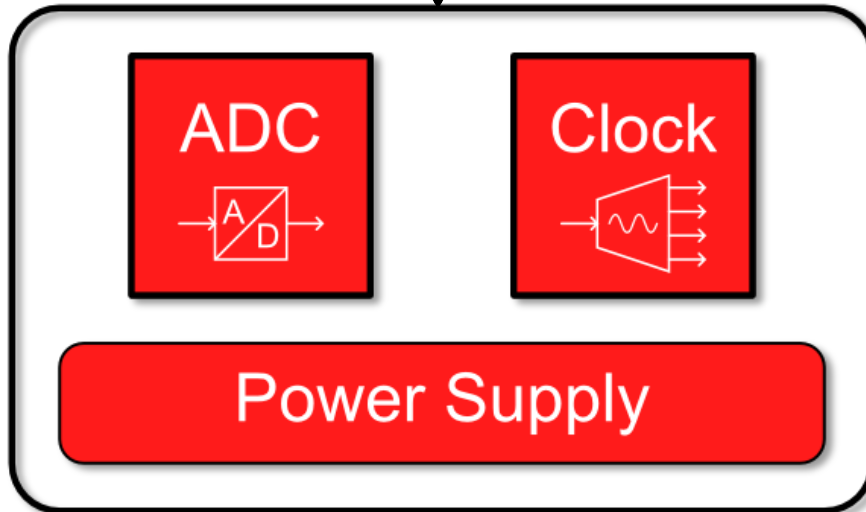
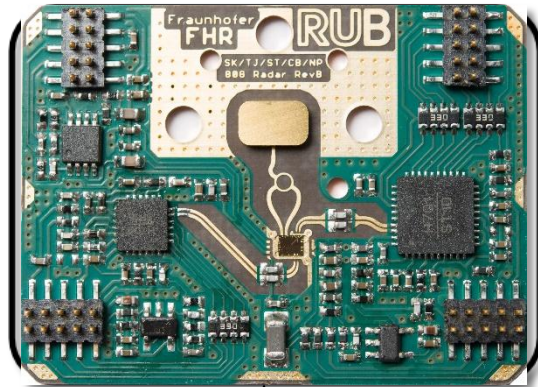
- Challenges:
  - High Data Rates: ADC/DSP Processing
  - Robust Industrial Designs
  - Complex RF-Backend



## Modular Design:

- 80 GHz Radar Frontend
  
- DSP Backend Versions:
  1. High Performance
  2. Miniaturized

Radar Frontend

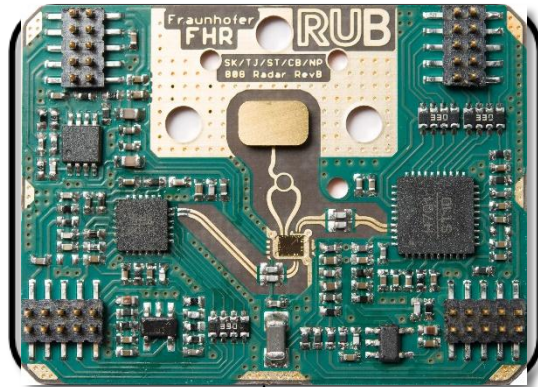


Processing Backend

## Modular Design:

- 80 GHz Radar Frontend
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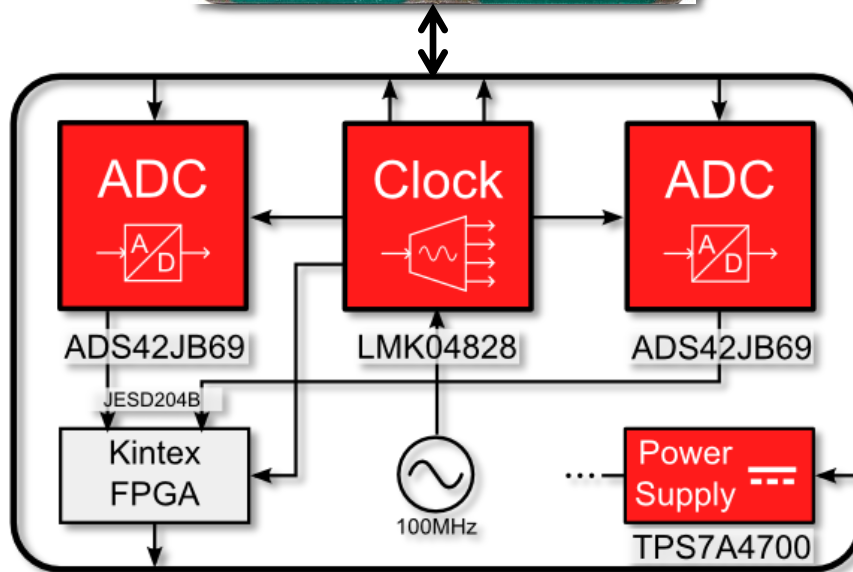
## Radar Frontend



- TI High Speed ADCs  
2x16 Bit @ 250MSPS

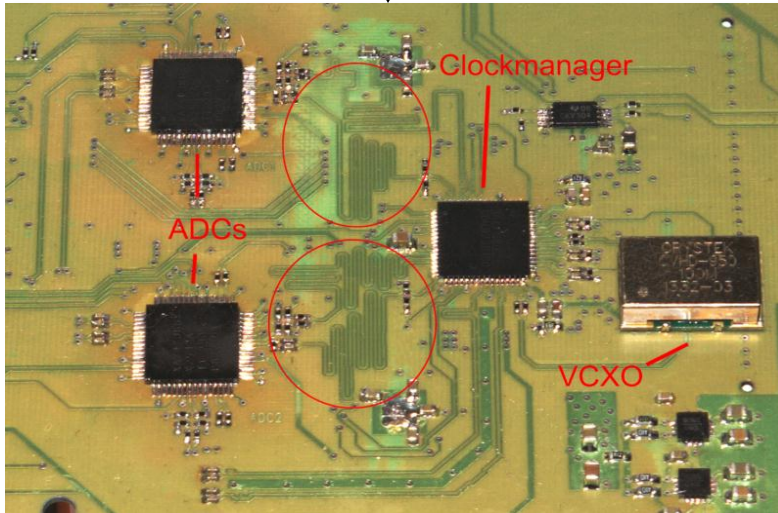
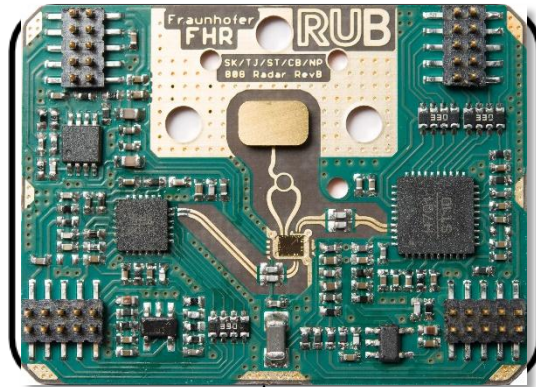
- TI Clock Manager
  - Ultra Low Jitter
  - Sync. Feature

- TI Power Supply  
 $4 \mu\text{V}_{\text{RMS}}$  RF LDO



## High Performance Backend

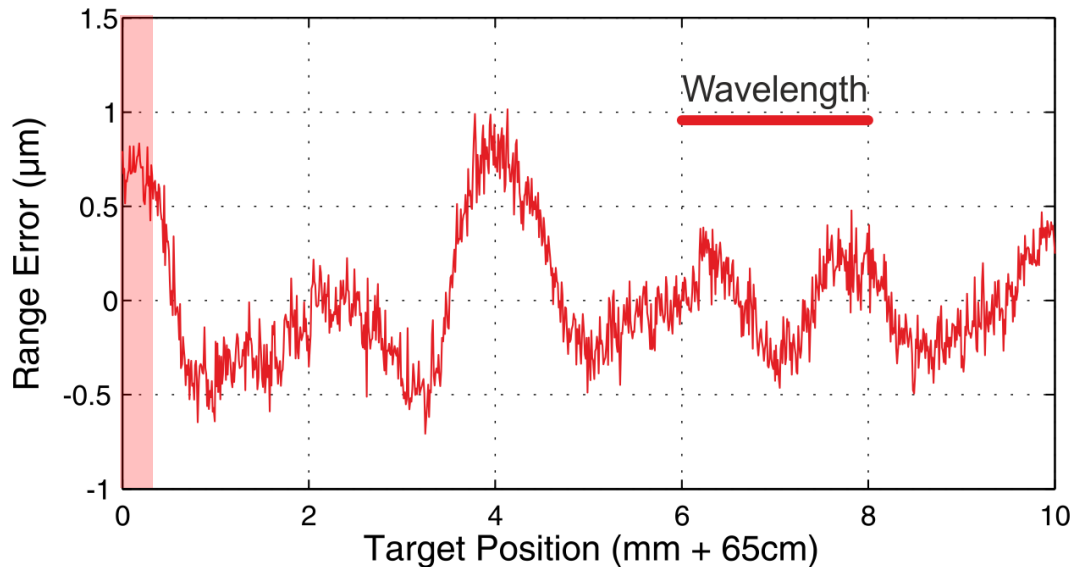
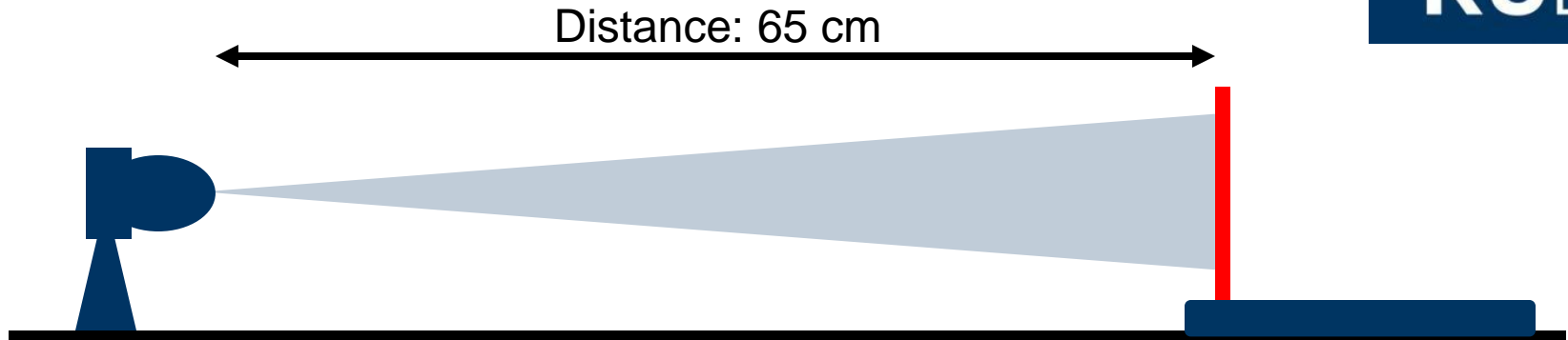
Radar Frontend



High Performance Backend

- TI High Speed ADCs  
2x16 Bit @ 250MSPS
- TI Clock Manager
  - Ultra Low Jitter
  - Sync. Feature
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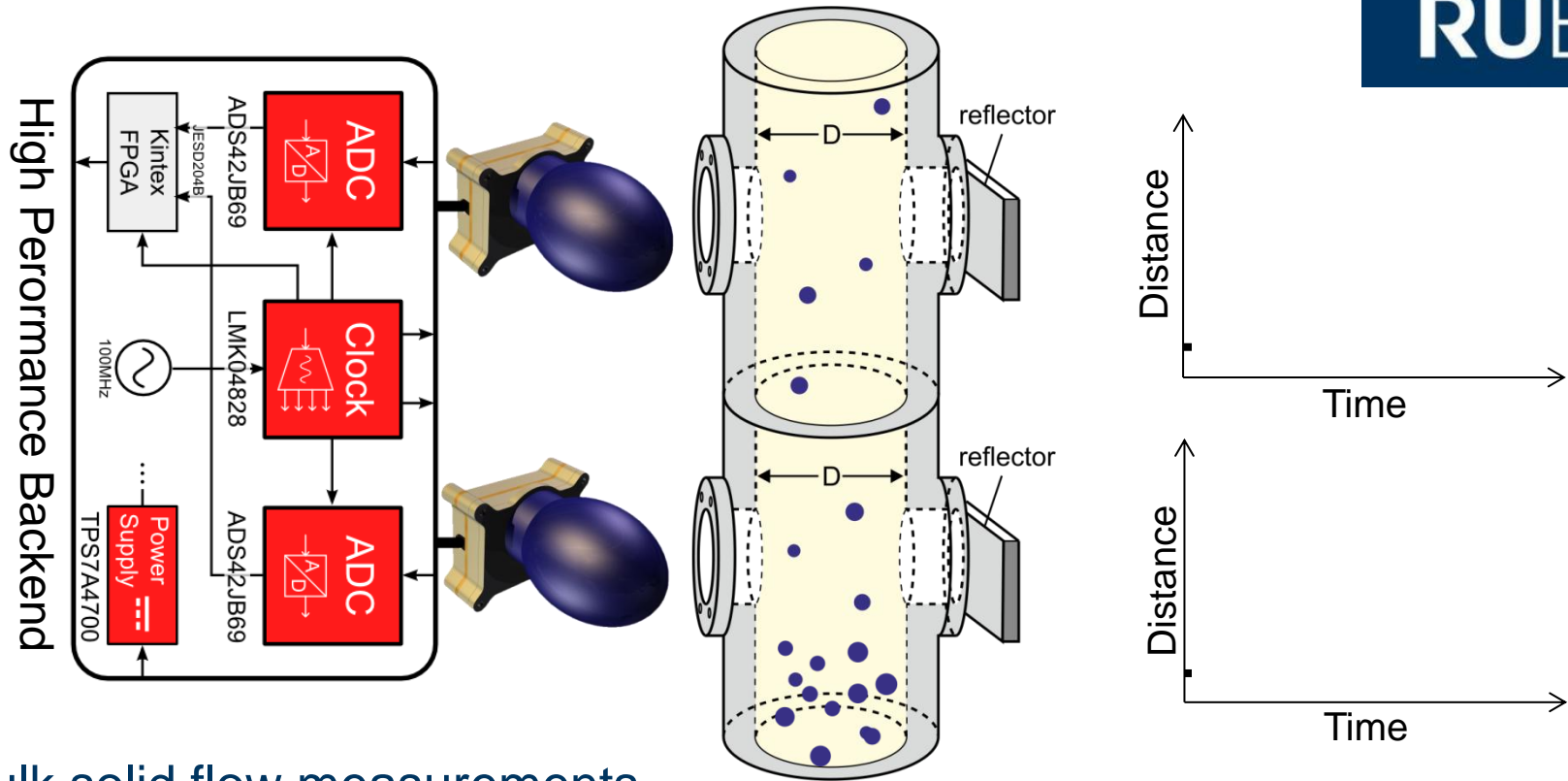
# Application – Distance Measurements



- Distance Measurement
- High precision glass scale linear positioning unit as reference with metal plate
- Range Accuracy: +/- 1µm



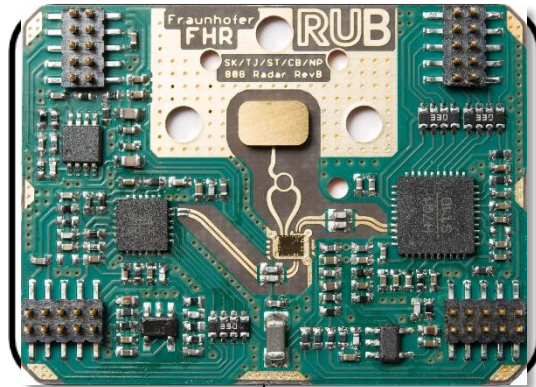
# Application – Flow Measurements



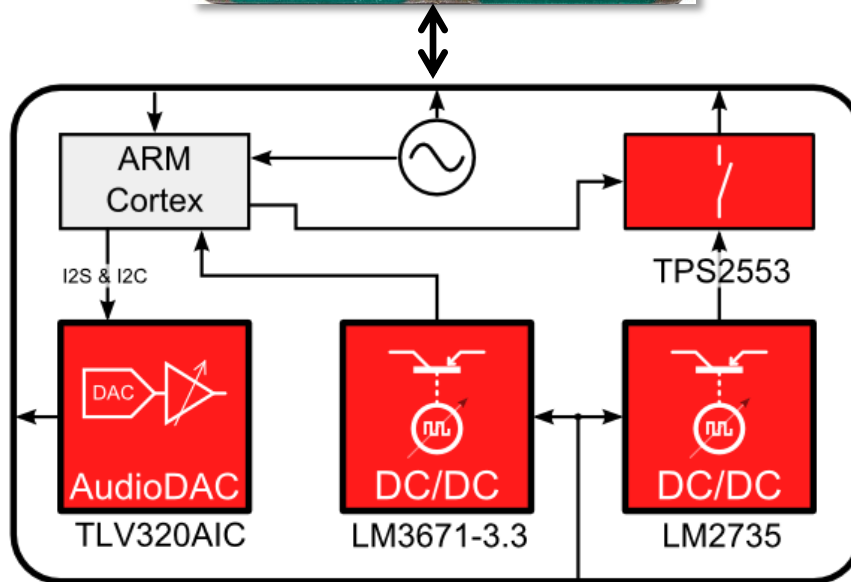
- Bulk solid flow measurements
- Correlation of two simultaneous radar measurements
- Flow changes propagation speed and causes distance deviations
- Real time DSP processing needed

# System Design – Miniaturized Backend

Radar Frontend



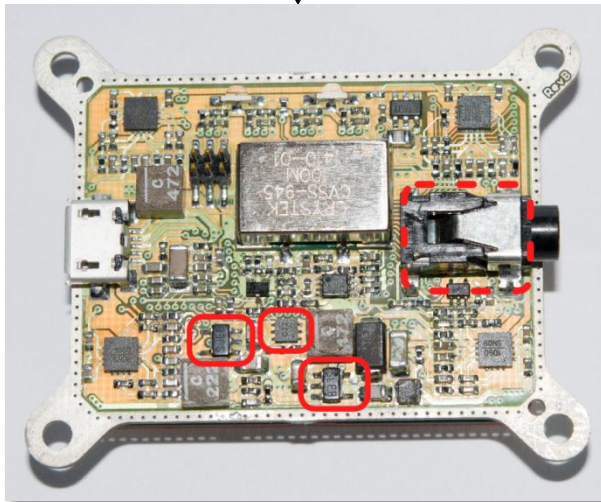
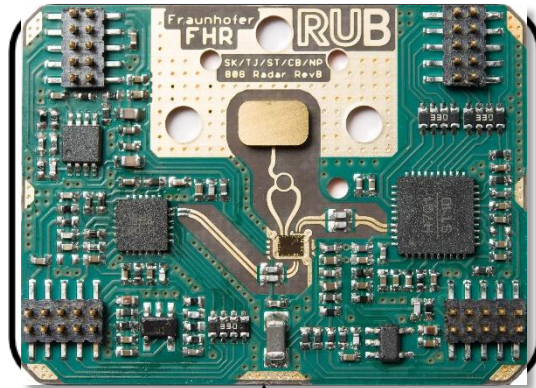
- TI Audio DAC Integrated HP-Amp
- TI Highside Switch Current Limiting
- TI Step Down DC/DC Low Iq & High Eff.
- TI Step Up DC/DC Single 5V Supply



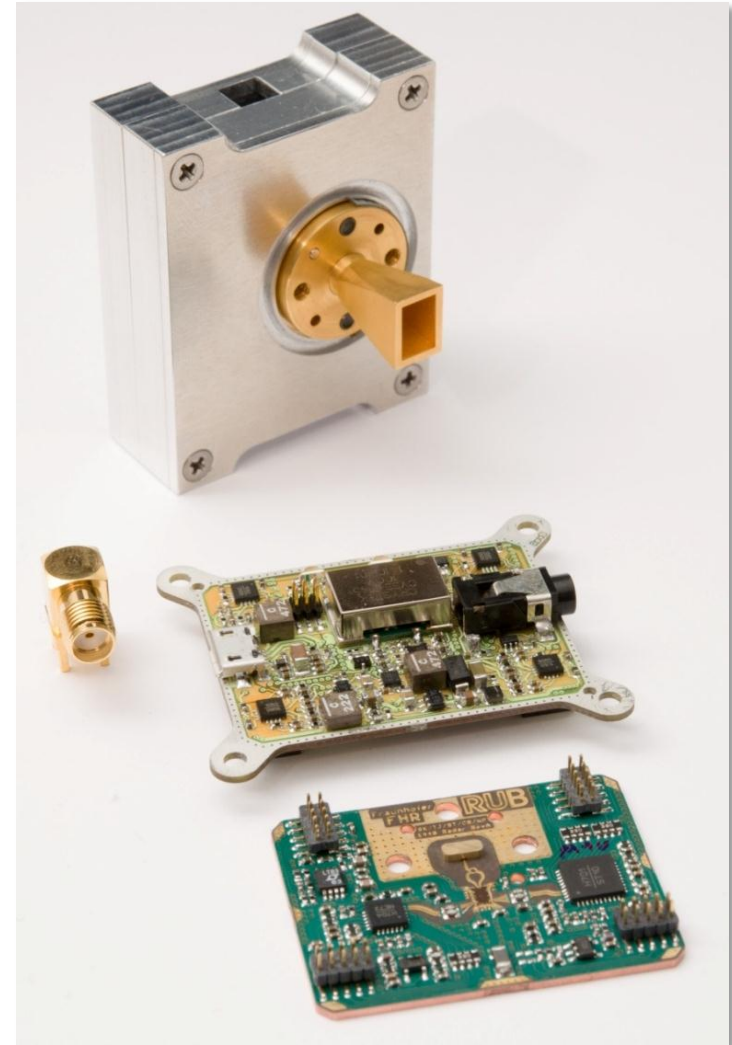
Miniaturized Backend

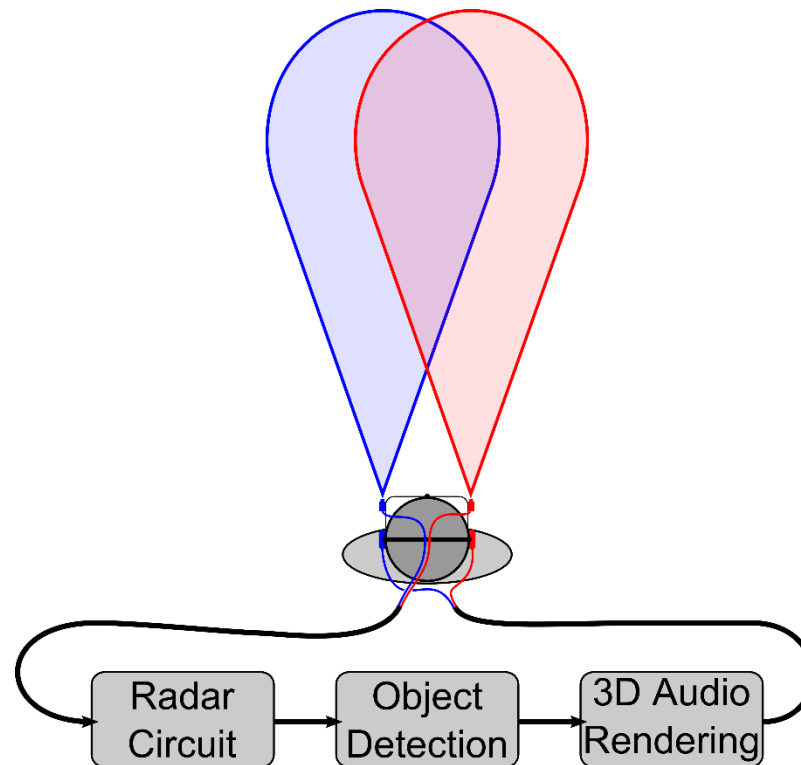
# System Design – Miniaturized Backend

Radar Frontend

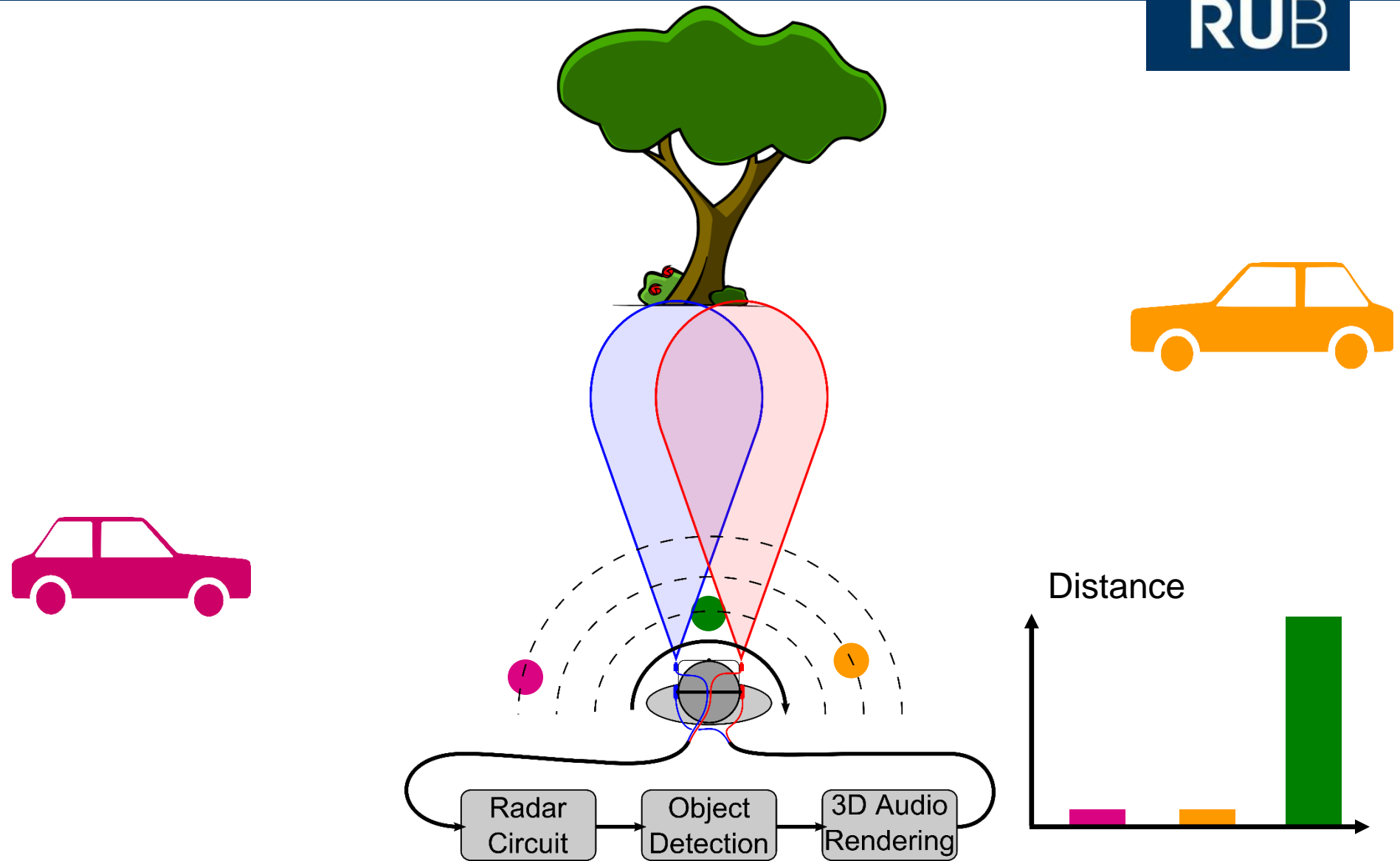


Miniaturized Backend





# Application – Vision Sensor



- Industrial Applications

- Precision distance measurements:

Accuracy:  $<1\mu\text{m}$

Repeatability:  $<70\text{nm}$

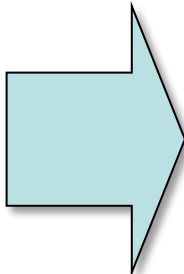
Measurement rate: 1 kHz

- Radar Vision Sensor

- Blind people
  - Emergency services

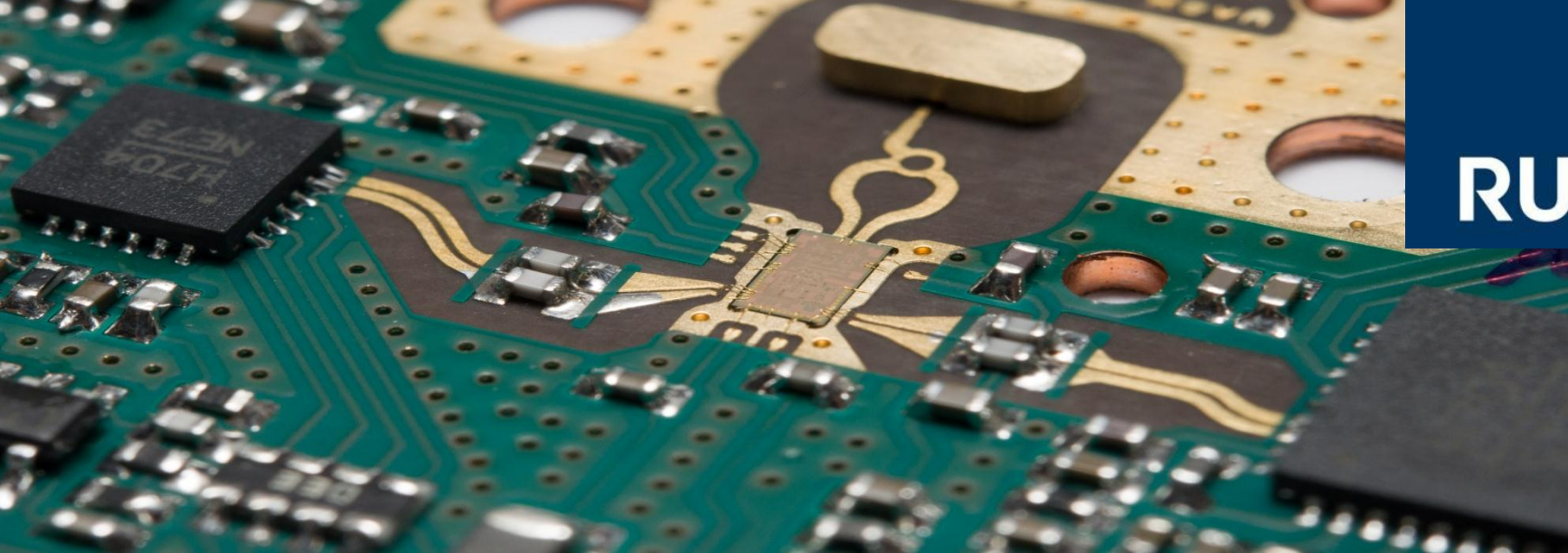
- Advantages FMCW Sensor

- Multi target
  - Doppler measurement



Combining latest semiconductor technologies with state-of-the-art components of TI's wide product portfolio allows new and interesting applications





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# Thank you for your attention!

## Questions?



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