

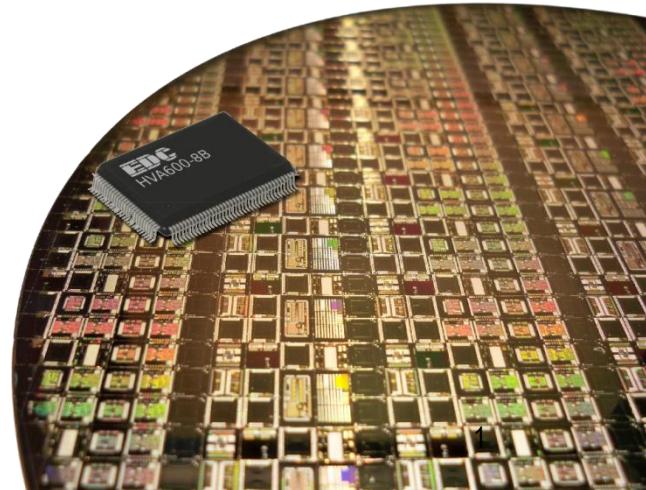
**EDC Electronic Design  
Chemnitz GmbH**

Ihr Dienstleister für die  
Entwicklung diskreter und  
integrierter elektronischer  
Schaltungen

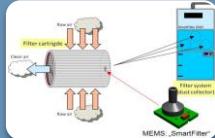
*„Smart Company  
- Special Solutions“*

A monolithic integrated MEMS in a  
350 nm technology for filter  
monitoring applications

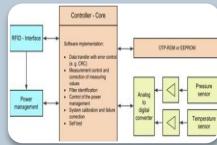
**„SmartFilter“**



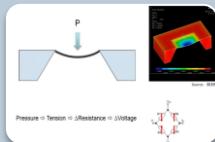
# Overview



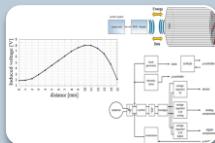
## Introduction



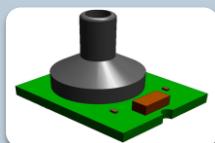
## System overview



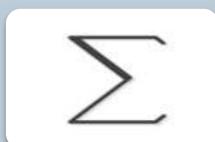
## Sensor integration



## Electronic integration

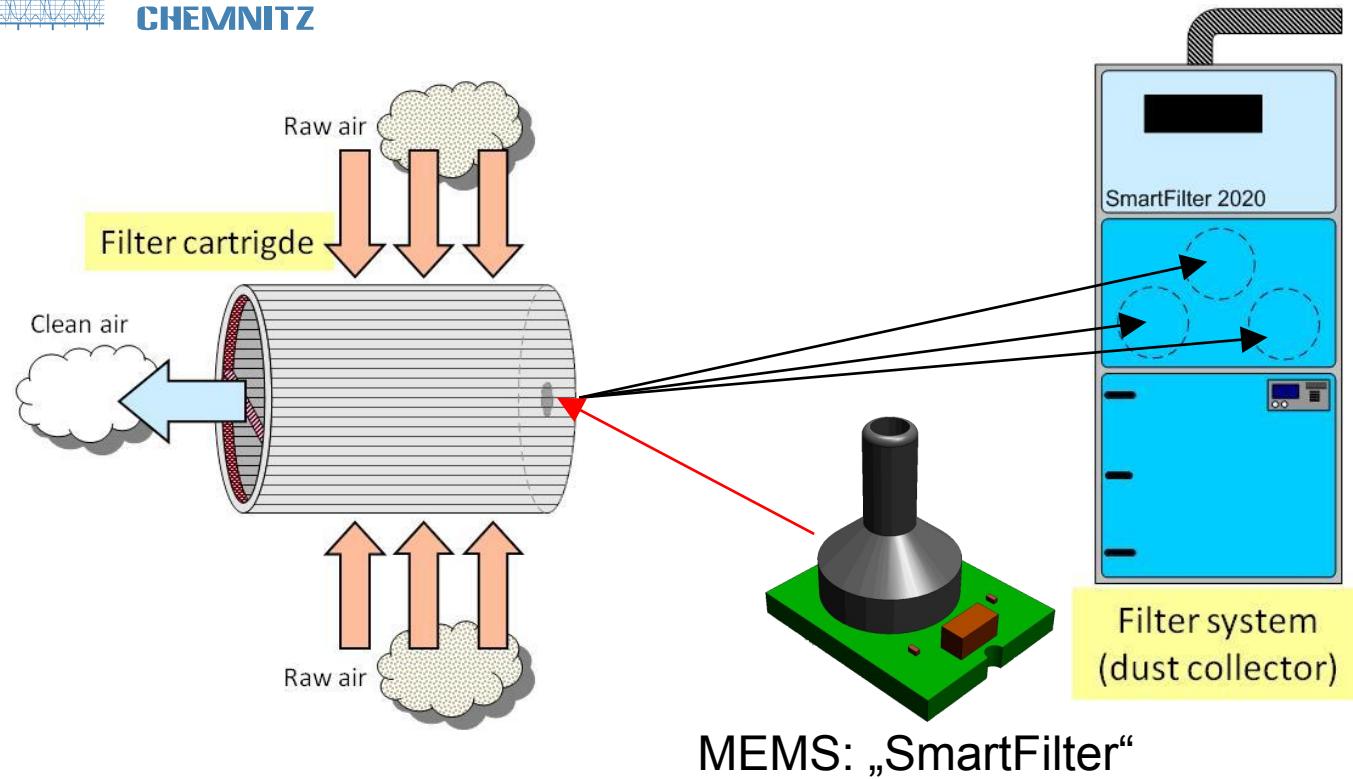


## Packaging concept



## Summary

# Introduction

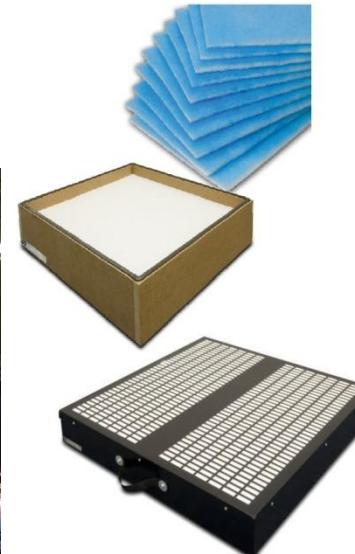


- Applicable in different filter systems and filter types
- Plug & Play solution for any BUS interfaces
- Throw-away product

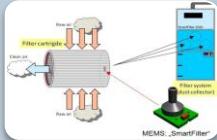
# Introduction

## Motivation:

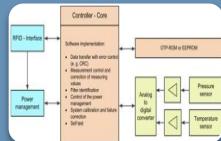
- Reduced maintenance effort
- Detection of differential pressure and temperature in the filter cartridge
- Auto-identification of the filter cartridge and the filter class
- High compliance to industrial health and safety standards
- Fire monitoring in each filter cartridge
- Condition monitoring (fill level) in each filter cartridge, therefore higher resource-efficiency



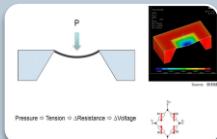
Source of the pictures: 



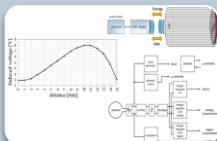
# Introduction



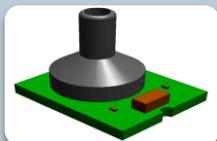
# System overview



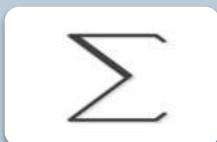
# Sensor integration



# Electronic integration



# Packaging concept

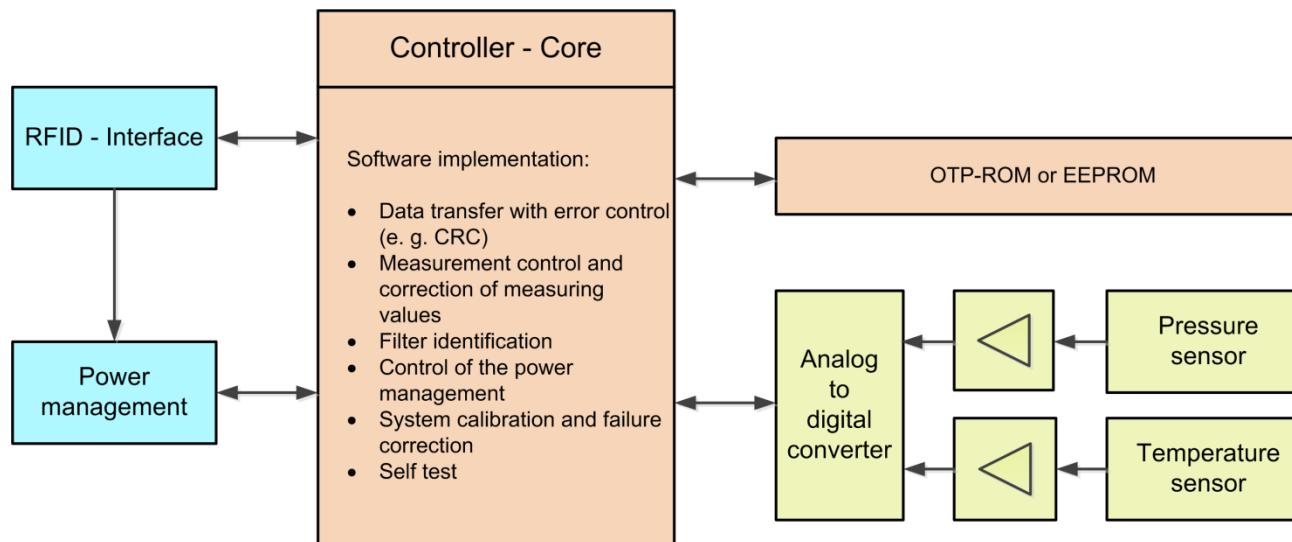


# Summary

# System Overview

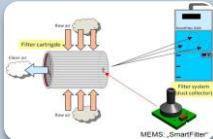
## ► Overview of the circuitry components:

- Differential pressure sensor and temperature sensor
- Sensor-Frontend including an Analog to Digital Converter
- Microcontroller core for signal processing
- RFID interface for data transfer and energy transmission (ISM wave band 13.56 MHz)

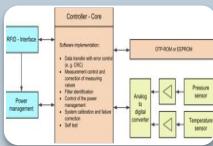


## ► Integration into X-FAB 350 nm mixed-signal CMOS technology

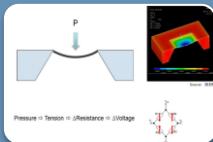




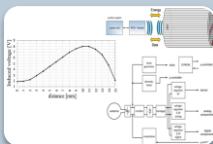
# Introduction



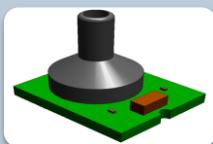
# System overview



# Sensor integration



# Electronic integration

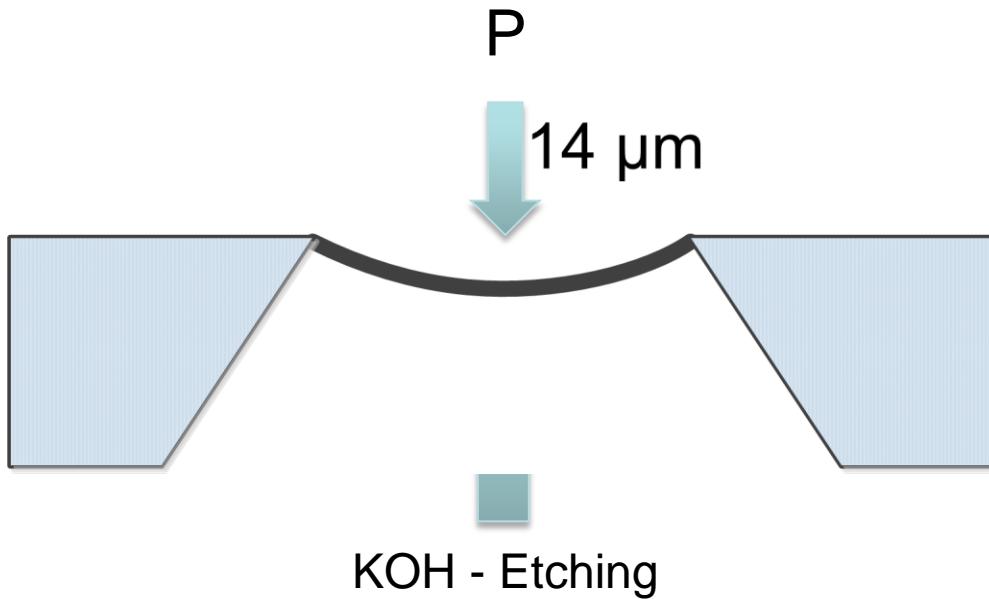


# Packaging concept

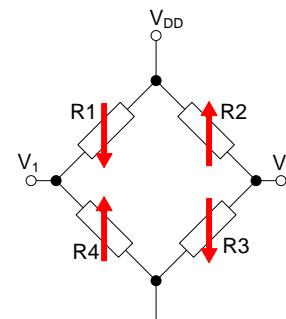
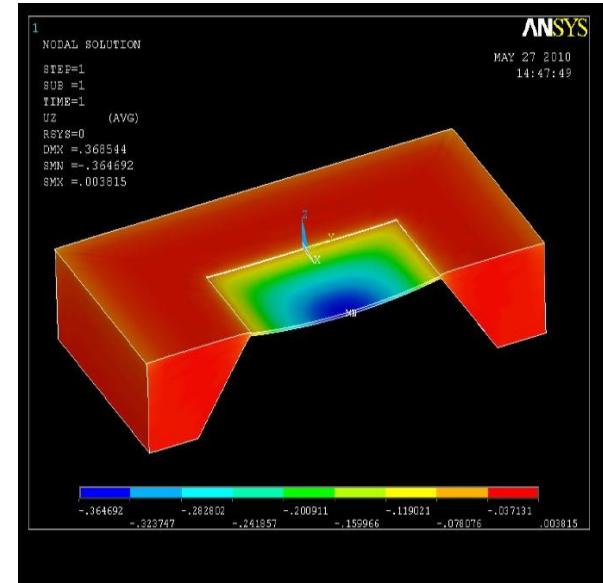


# Summary

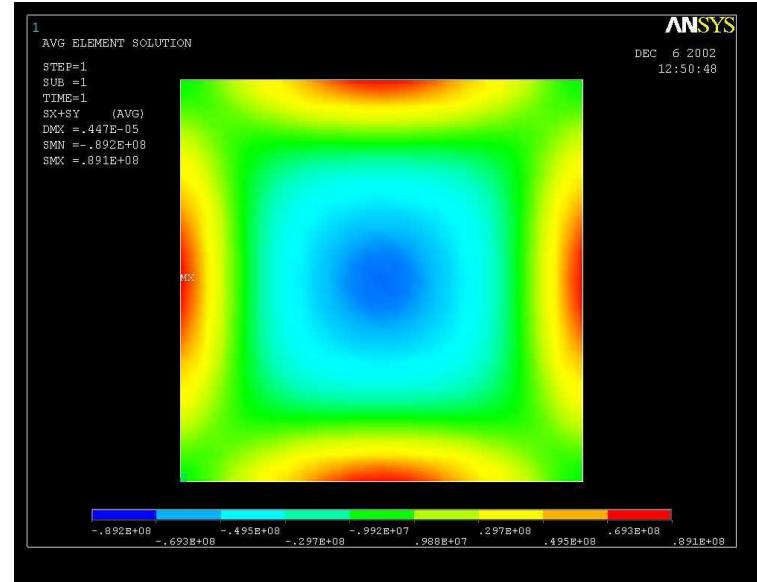
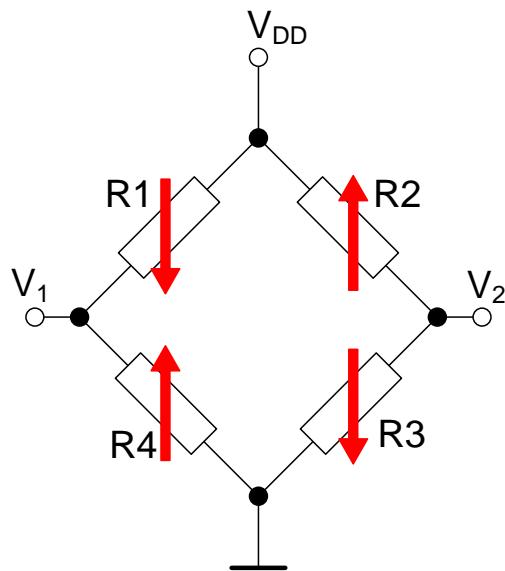
# Sensor Integration



Pressure  $\Rightarrow$  Tension  $\Rightarrow$   $\Delta$ Resistance  $\Rightarrow$   $\Delta$ Voltage



# Sensor Integration



Source:  **FAB**  
JOED-SIGNAL FOUNDRY EXPERTS

$$\frac{\Delta R}{R} = \prod l * Sl + \prod t * St$$

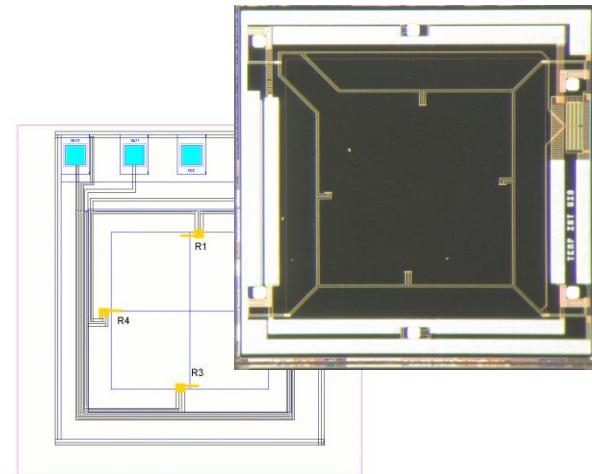
$$\begin{aligned}\prod l &= 71,8 \cdot 10^{-11} / \text{Pa} \\ \prod t &= -66,3 \cdot 10^{-11} / \text{Pa}\end{aligned}$$

$l, t \dots$  phase vector,  $\pi \dots$  piezo coefficient,  $S \dots$  strain

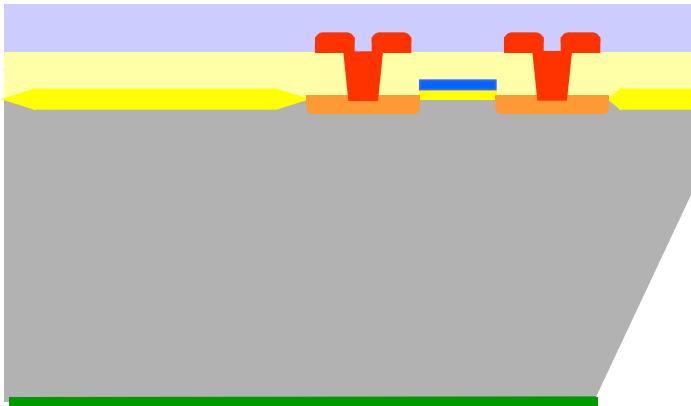
# Sensor Integration

## Sensor requirements

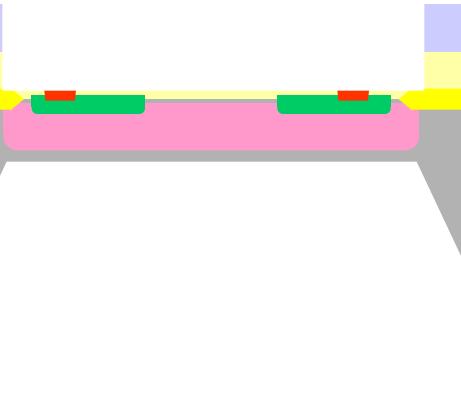
- High sensitivity (up to 100 mV/V/Bar)
- Small offset
- High linearity



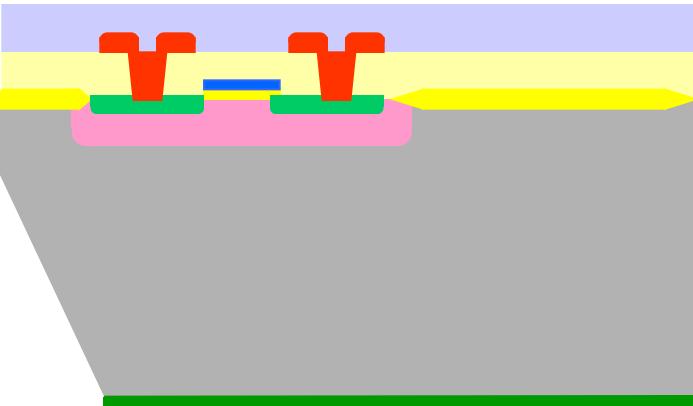
**NMOS**



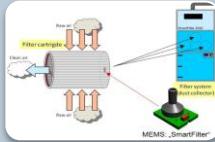
**Pressure-Sensor**



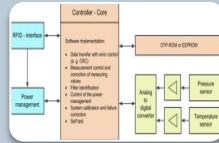
**PMOS**



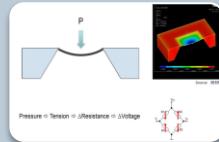
Source:  X-FAB  
ANALOG SIGNAL FOUNDRY EXPERTS



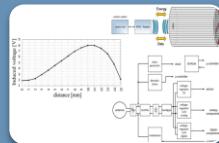
# Introduction



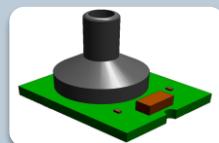
# System overview



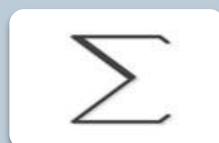
# Sensor integration



# Electronic integration



# Packaging concept

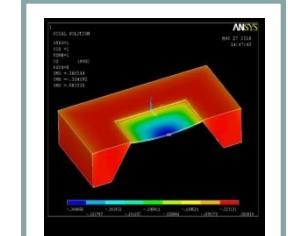
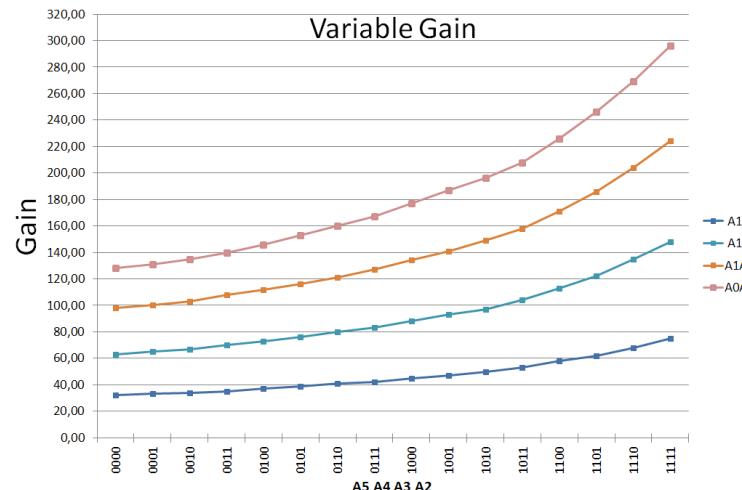
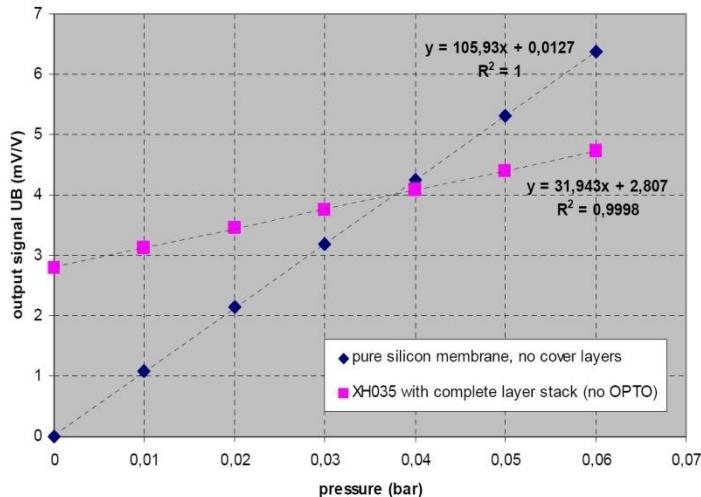


# Summary

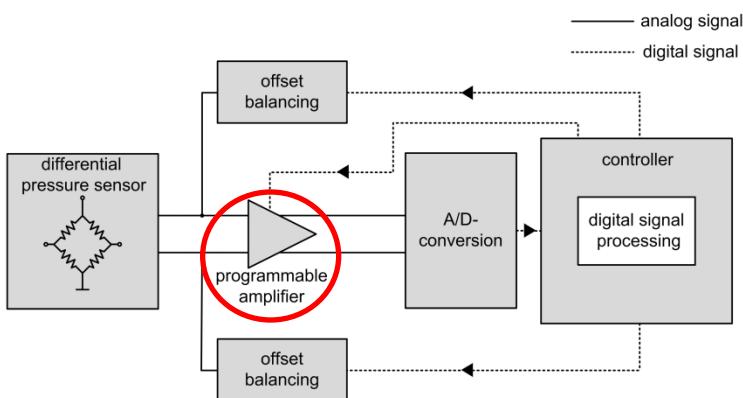
# Electronic Integration

## Sensor-Frontend

fluctuating sensitivities → programmable amplification



Source:  FAB  
ANALOG SIGNAL FOUNDRY EXPERTS

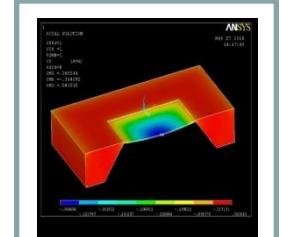
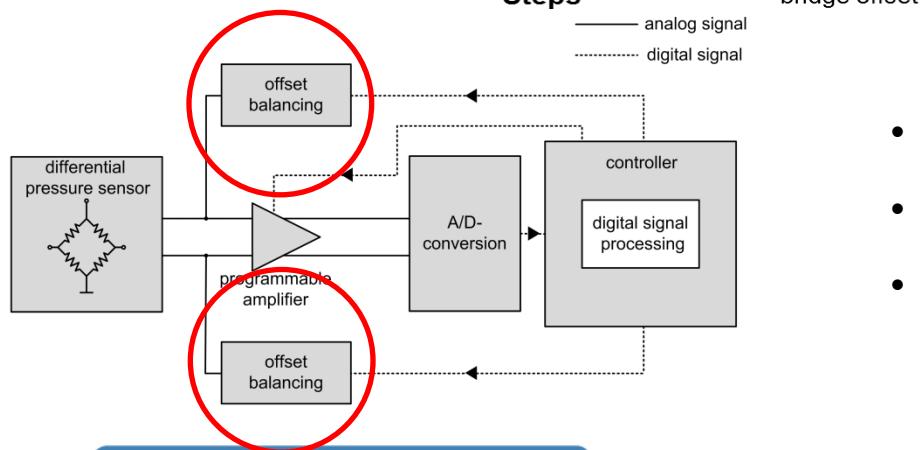
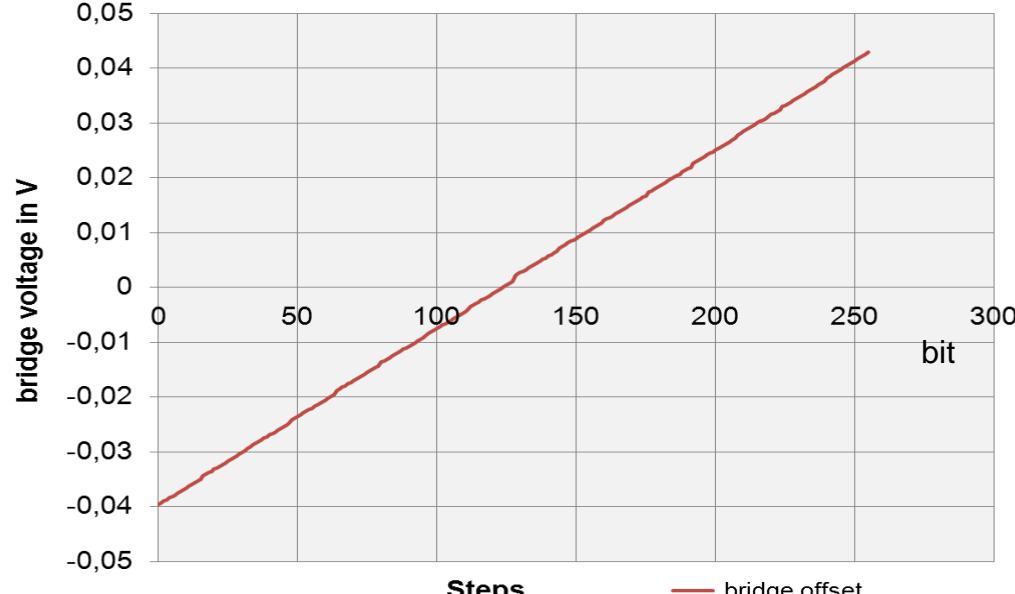


- 6 bit resistance network
  - 2Bit coarse, 4Bit fine
- gain range 27 - 240

# Electronic Integration

## Sensor-Frontend

fluctuating resistance  autonomous offset adjust  
**8 bit offset adjust**



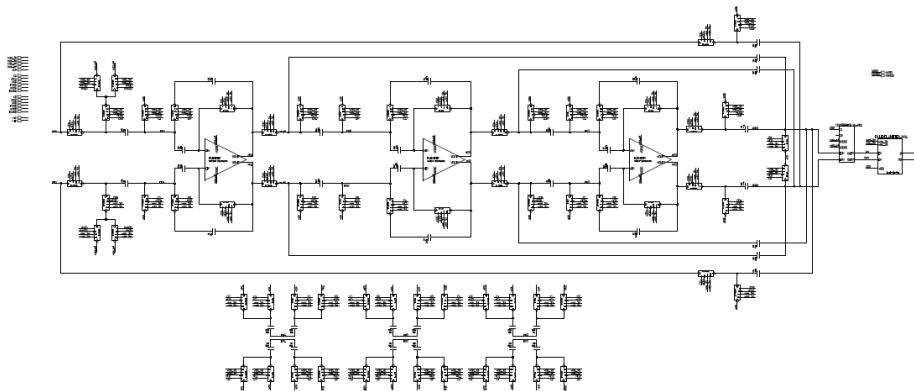
Source:   
**X-FAB**  
 MIXED-SIGNAL FOUNDRY EXPERTS

- voltage supply of 5 V
- resistance of 16 kΩ

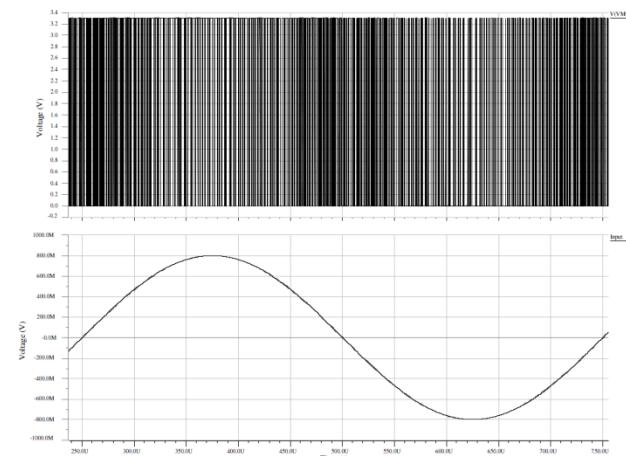
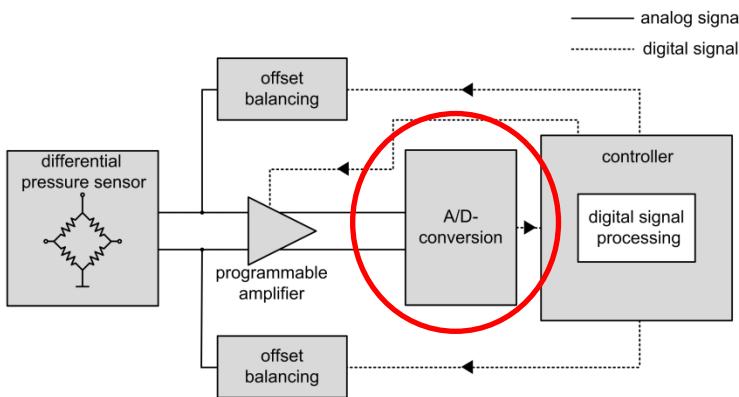
- 8 bit W-2W current steering
- Offset compensation up to 80 mV
- Minimum resolution of 0.32 mV

# Electronic Integration

## Sensor-Frontend



- Sigma Delta ADC 1st order
- Variable sample rate
- 16 Bit resolution

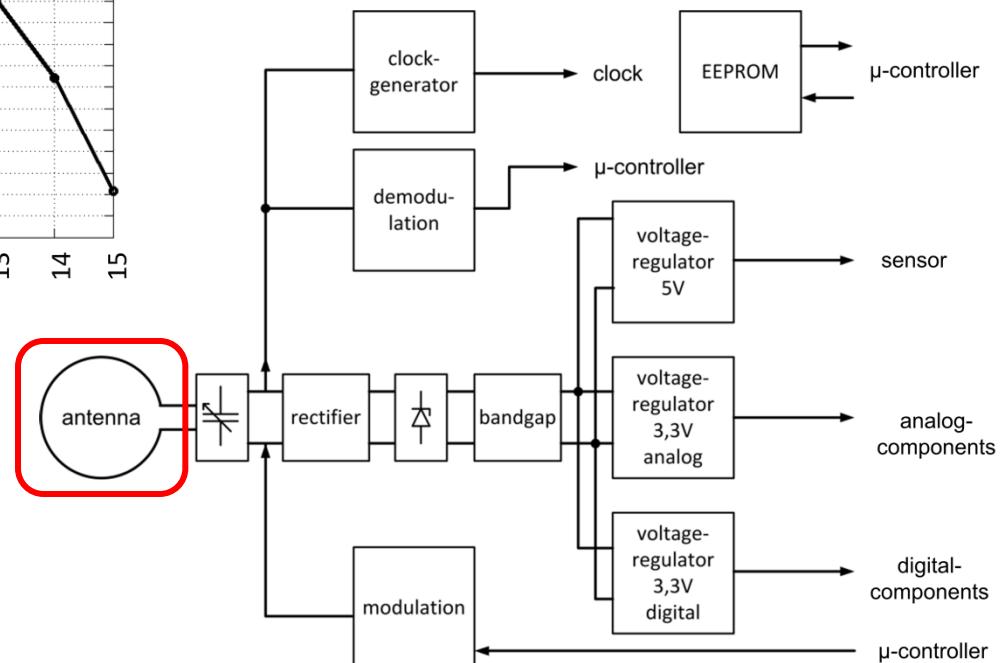
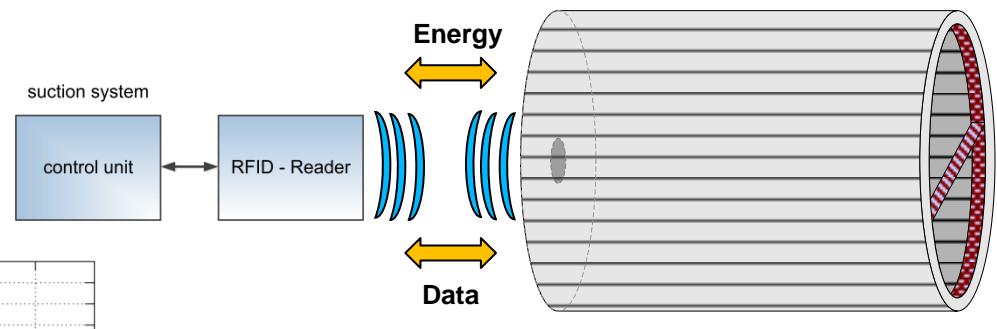
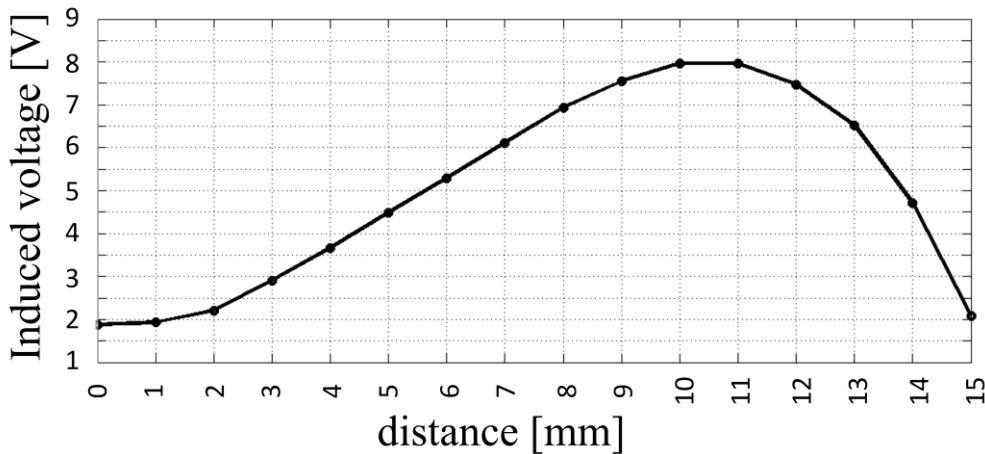


# Electronic Integration

## RFID-Interface

Components:

- Antenna

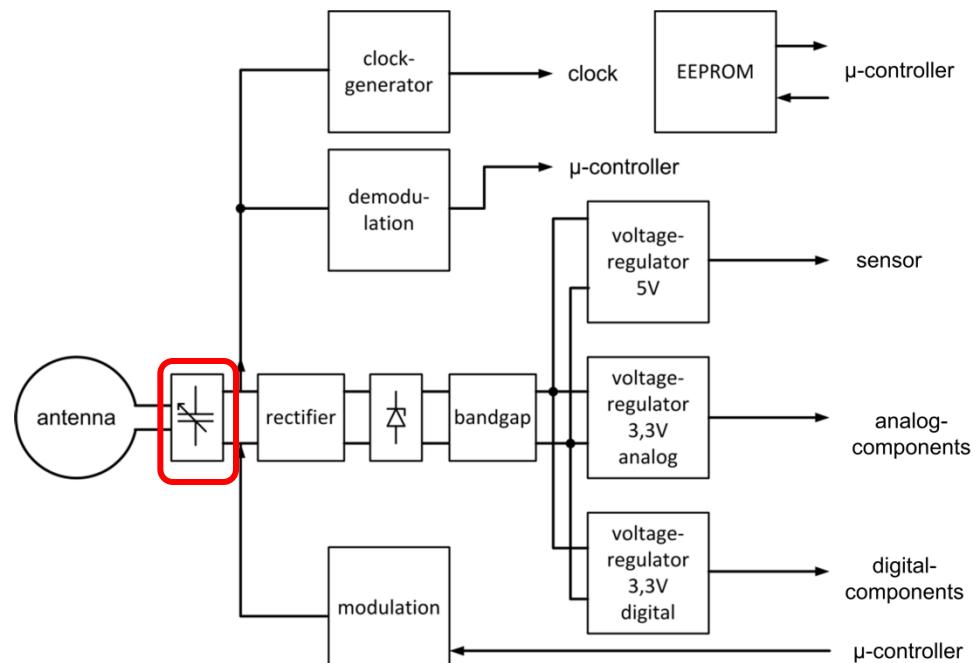
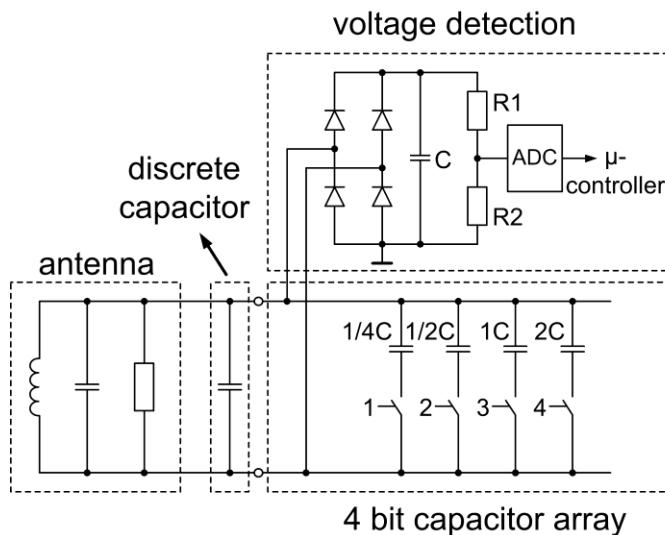
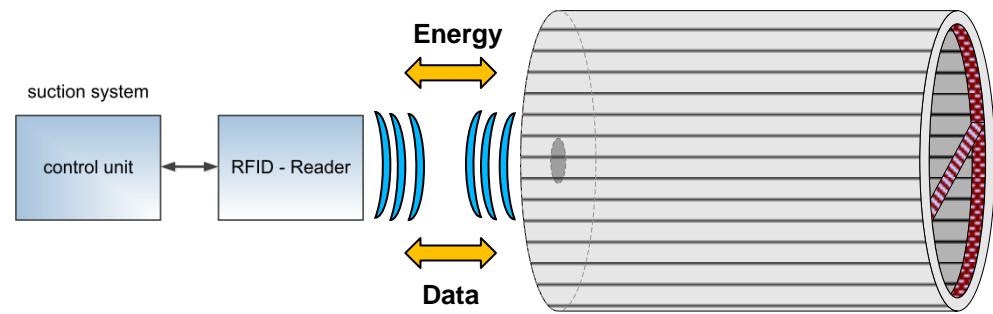


# Electronic Integration

## RFID-Interface

Components:

- Antenna
- Adaption circuitry
  - Tuning to resonance frequency
  - max. transfer of energy

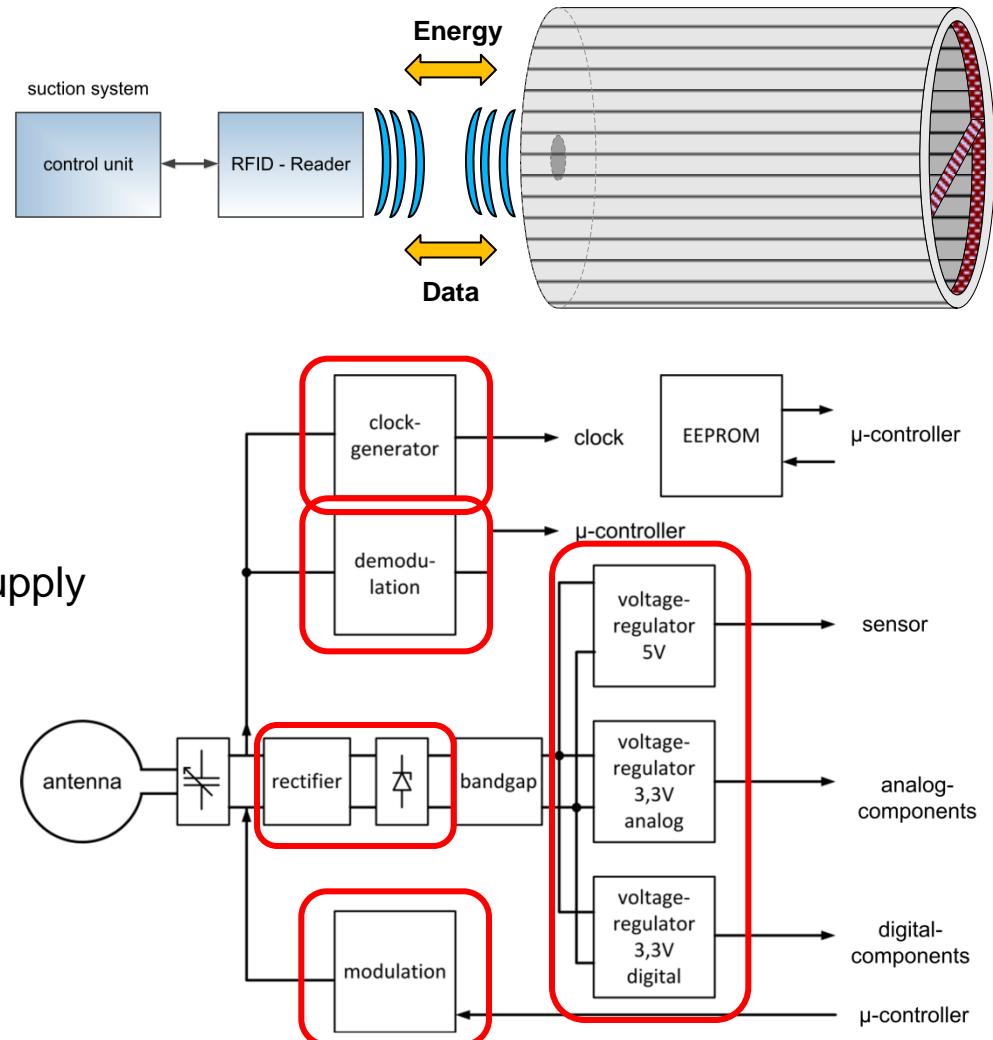


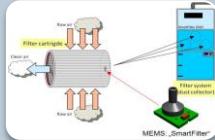
# Electronic Integration

## RFID-Interface

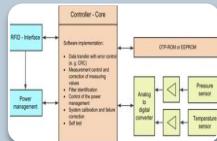
Components:

- Antenna
- Adaption circuitry
  - Tuning to resonance frequency
  - max. transfer of energy
- Rectifier and voltage limiter
- Voltage regulators
  - 5V bridge voltage
  - 3.3V analog and digital voltage supply
- Circuitries for data transfer
  - 10% – 30% ASK modulation
  - ISO 15693
- Clock generator
  - Frequency divider
  - 13.56 MHz

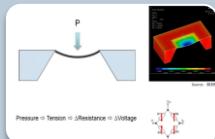




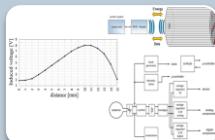
## Introduction



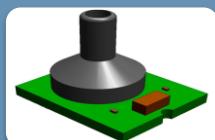
## System overview



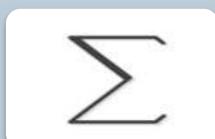
## Sensor integration



## Electronic integration

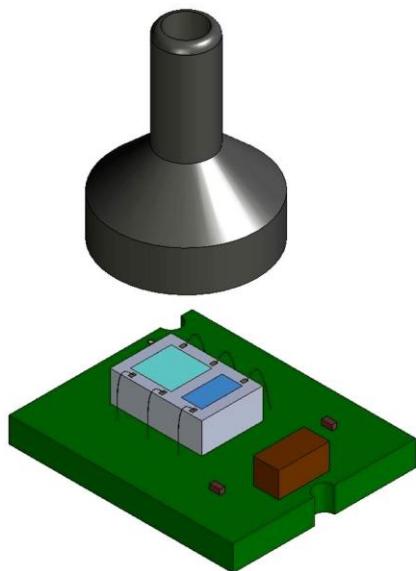
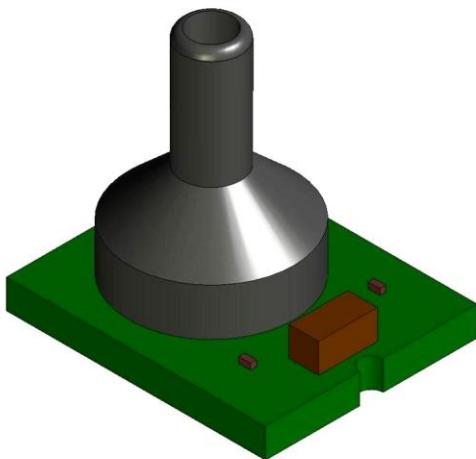
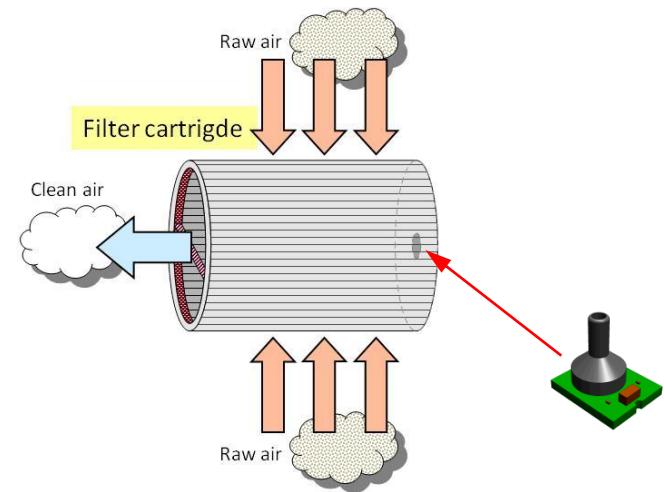
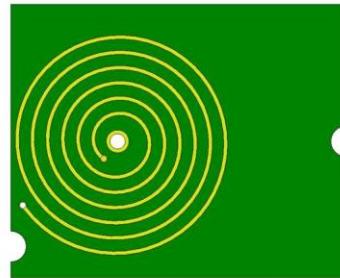
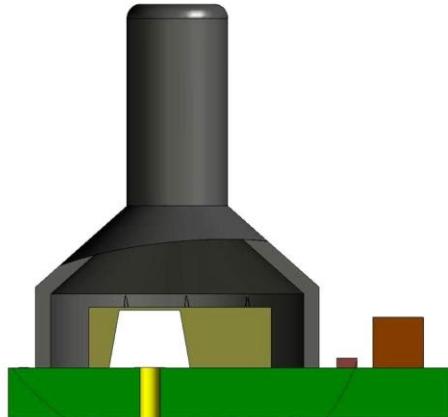


## Packaging concept



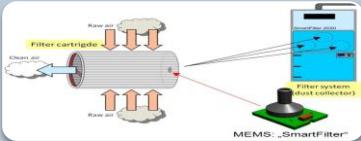
## Summary

# Packaging Concept

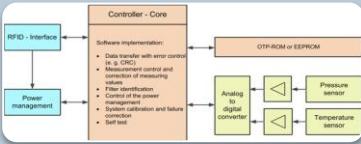


- PCB with antenna serves as a base plate for MEMS, ASIC and discrete elements
- Encapsulation of the system
  - Connection to raw air side
  - Protection against pollution

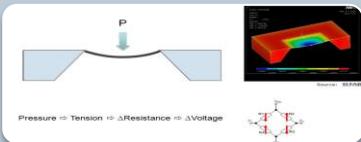
# Conclusion



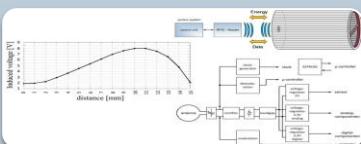
## Introduction



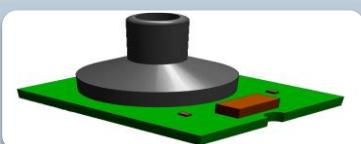
## System overview



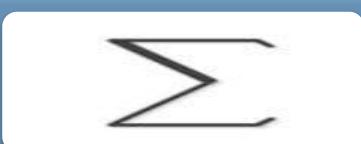
## Sensor integration



## Electronic integration



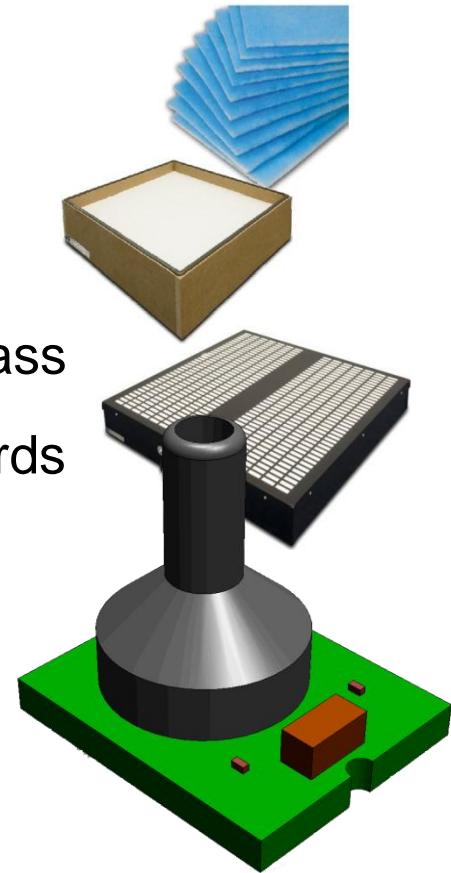
## Packaging concept



## Summary

# Summary

- Reduced maintenance effort and condition monitoring in each filter cartridge
- Detection of differential pressure and temperature in the filter cartridge
- Auto-identification of the filter cartridge and the filter class
- High compliance to industrial health and safety standards
- Fire monitoring in each filter cartridge
- Plug & Play solution for any BUS interfaces
- Data logging in the filter cartridge (working time, pollution rate, temperature cycle ...)
- *SmartFilter will be available at 2013*



# Cooperation and Foundation

GEFÖRDERT VOM



Bundesministerium  
für Bildung  
und Forschung



CHEMNITZ UNIVERSITY  
OF TECHNOLOGY

## KMU Innovativ - Verbundprojekt

*FKZ: 13N10878*

