

# Input/Output

## 18-849b Dependable Embedded Systems

Leo Rollins

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Required Reading: Toleration Sensor Timing Faults in Highly Responsive Hard Real-Time Systems, Polenda, S., IEEE Transactions on Computing, 44(2), Feb 1995, pp 181-191.

Best Tutorial: Fieldbus Tutorial, <http://rolf.ece.curtin.edu.au/~clive/Fieldbus/fieldbus.htm>, 1995

Authoritative Books: Analog-to-Digital Conversion, A Practical Approach, Daugherty, K. M., McGraw Hill, 1995

Process/Industrial Instruments and Controls Handbook, ed. Considine, D. G., McGraw Hill, 1993

# Overview

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- ◆ Introduction
- ◆ Key Concepts
  - Reliable I/O
  - Fieldbus Trend
  - Smart Sensors and Actuators
- ◆ Tools / Techniques / Metrics
- ◆ Connections
- ◆ Conclusion
- ◆ Paper Discussion



Rosemount intelligent vortex flow sensor with readout

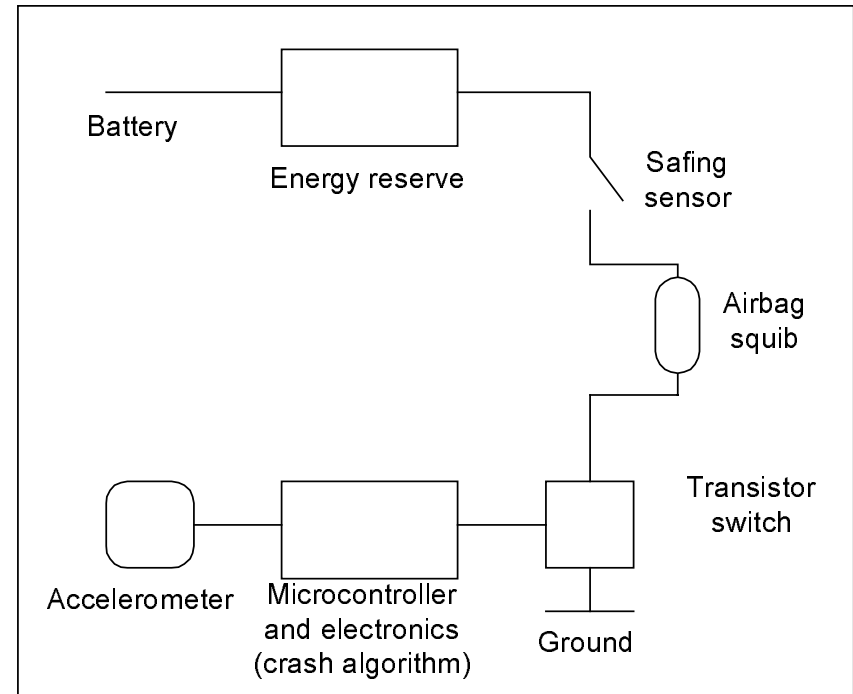
# Introduction

## ◆ I/O Scope

- Physical measurement
- Digital Conversion
- Delivery to control

## ◆ Make I/O Dependable?

- Individual I/O design
- Introduce Redundancy
  - Second sensor
  - Mechanical interlocks
  - Manual controls



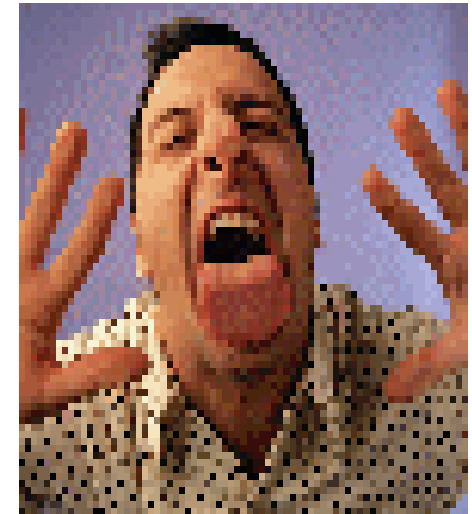
Source: Vehicle sensing gets an inflated image, Holligan, J., Sensor Review, 16(4), 1996, p. 32.

# Strange Sensors

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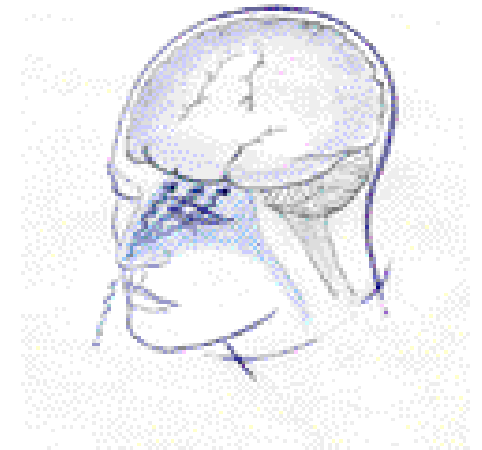
## ◆ Electronic tongue

- Research project
- “... taste of foodstuffs such as beer, sake, coffee, mineral water, milk and vegetables can be discussed quantitatively...”



## ◆ Electronic nose

- Nordic Sensor Technologies AB
- Medical diagnostics and food industry



# Reliable Individual I/O

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## ◆ Major I/O Requirements

- EMC
- Noise
- Shock / Vibration / Seismic \*
- Environment
- Accuracy and Resolution \*
- Conversion Speed \*
- Drift
- Diagnostics / Error Detection \*
- Calibration / Testing \*
- Fail-safe techniques \*

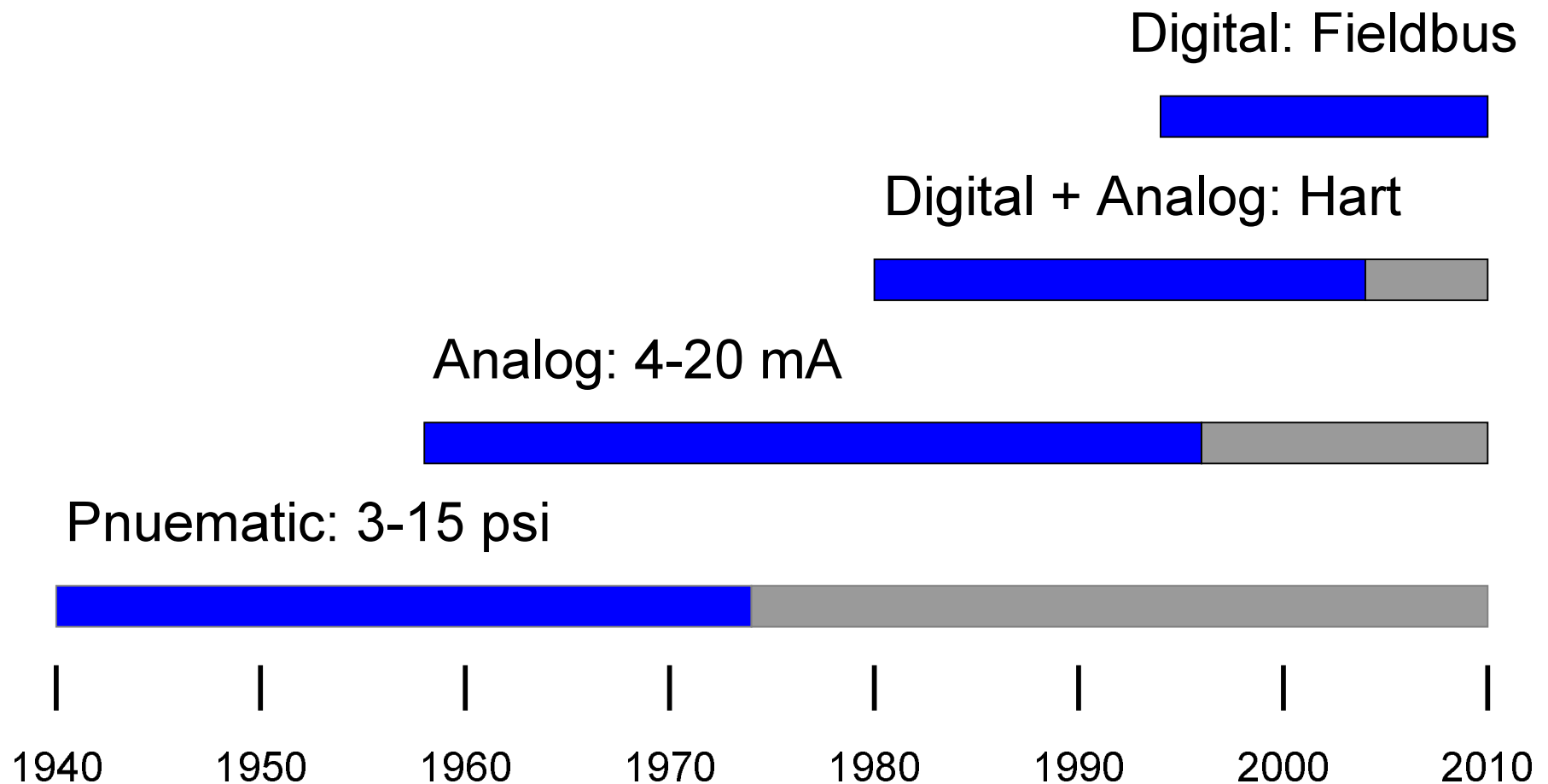


Rosemount insertion  
Flowmeter

\* Embedded  
challenges

# Trends in I/O Signaling

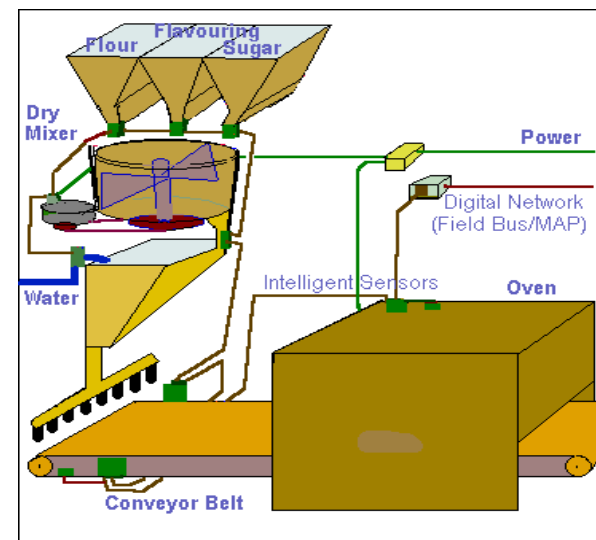
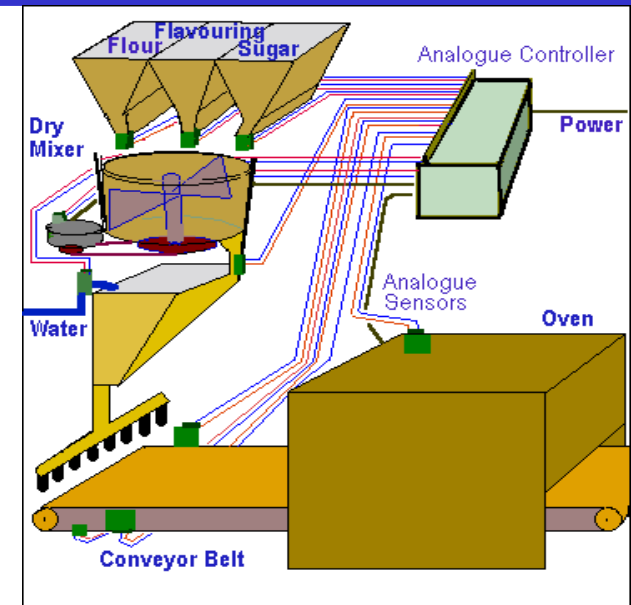
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Source: Fisher Controls, Understanding Fieldbus  
<http://www.fisher/products/produpdf/fbus-all.pdf>

# Fieldbus

- ◆ What is it?
  - Networking sensors and actuators
  - Implies intelligence
- ◆ Advantages
  - Wiring reduction (installation cost)
  - Config and calib (maint cost)
  - Flexibility
  - Interoperability
- ◆ Standardization
  - ISP + WorldFIP -> FF (ISA SP50)
  - Profibus leads Europe (41% Market)
  - Over 200 fieldbusses being used



# Smart Sensors

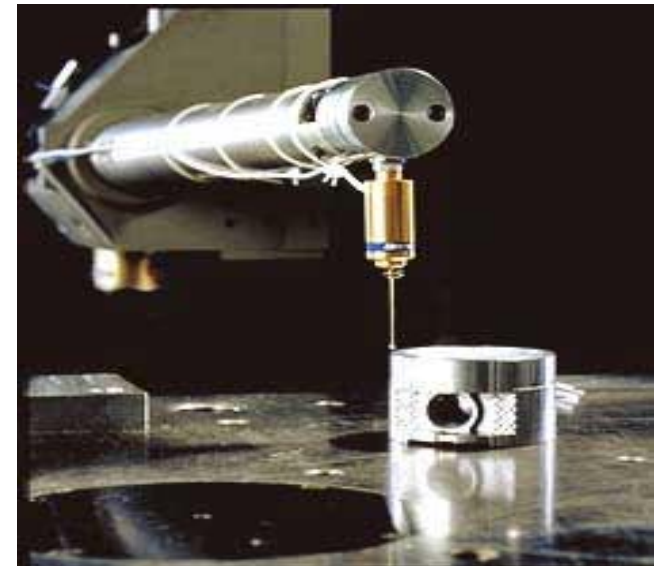
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## ◆ Definitions

- “... highly sophisticated sensing devices capable of signal analysis, self-diagnosis, and digital communication.”  
Lawrence Holloway (1993)
- Sensor takes over some functionality of control system

## ◆ Advantages

- Off-load main controller
- Higher conversion rates
- Storage of samples
- Self-Diagnostics
- Electronic data sheets
- Safety - Control on network loss



Non-contact part measurement



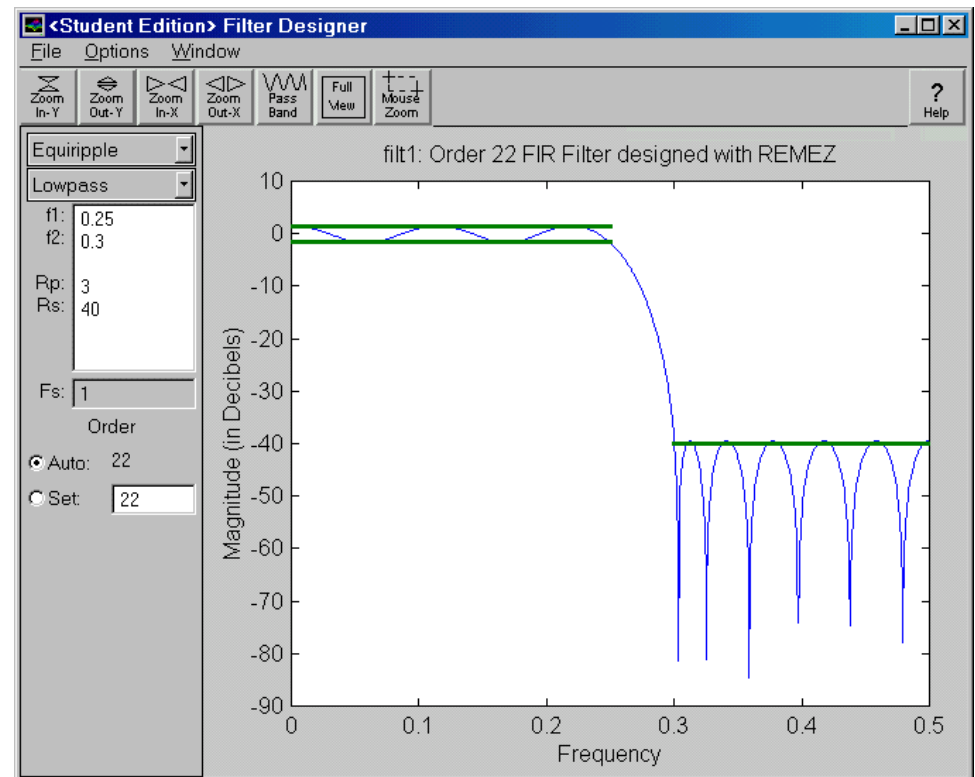
# Tools / Techniques / Metrics

## ◆ Tools / Techniques

- Config for fieldbus (Every vendor has one)
- Transducer techniques
- A/D conversion
- DSP
- Filters
- Control Theory

## ◆ Metrics

- SNR, ENOB
- Dynamic Range
- Conversion Speed

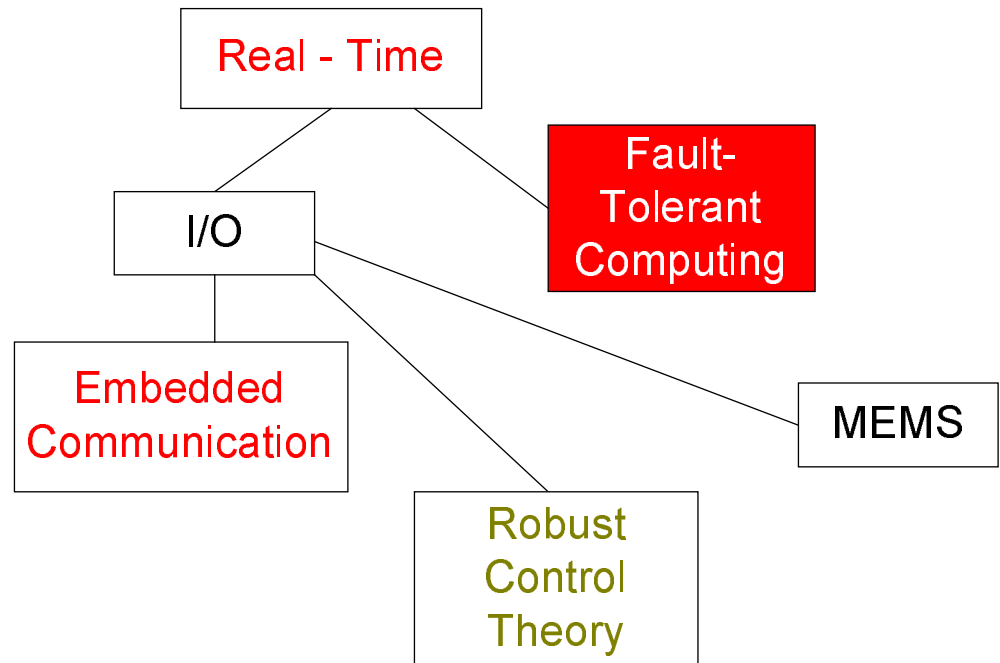


Matlab Filter Design Tool

# Connections

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- ◆ Communication
  - Fieldbus
- ◆ Real-Time
  - Usually RT controls
- ◆ Control Theory
  - Sampling (stability)
- ◆ MEMS



# Conclusions

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- ◆ I/O dependability achieve through:
  - Highly reliable individual components
  - Redundancy techniques: diversity, interlocks and human overrides
- ◆ Trend toward intelligent networked devices promises cost reduction and increased functionality
- ◆ Embedded I/O becomes plug-n-play?
- ◆ Future work
  - DASP - Digital Alias-Free Signal Processing

# Paper: Timing Faults...

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- ◆ Most systems only consider value faults
- ◆ Merging of Event Based and Time Based Communication to balance efficiency vs predictability
- ◆ Require operating system and interrupts?
- ◆ Limited to specific sensor types (speed, rotation)?