SMART SENSORS AND ACTUATORS
INTRODUCTION

WHAT ARE SENSORS AND ACTUATORS?

- A sensor is a device or system that responds to a physical, chemical, electrical, or optical quality to produce an output that is a measure of that quality.
- Sensors are needed to measure the critical parameters of the environment, machines, and the human.
- Devices which perform an output function are generally called **Actuators** and are used to control some external device in response to the signal of the sensor.
- Both sensors and actuators are collectively known as **Transducers**
Figure: An information-processing model for sensor-based situational awareness.
PARAMETERS OF A SENSOR

The parameters of importance largely depend on the application. These parameters include:

- Sensitivity
- Stability
- Accuracy
- Hysteresis
- Drift
- Cost, size, weight
- Range (span)
- Resolution
- Reliability
Desirable characteristics of a practical sensor

- High reliability
- Reduction of cost
- Smaller size and Less weight
- Intelligent decision making

What is the solution?
The solution lies in “Smart Sensor”
What are Smart Sensors?

- A sensor with built-in intelligence.
- According to Lawrence Holloway “highly sophisticated devices capable signal analysis, self-diagnosis and digital communication”.

- According to M. Griffiths - Smart Sensors are sensors and instrument packages that are
  - microprocessor driven.
  - include features such as communication capability on-board diagnostics that provide information to a monitoring system and/or operator to increase operational efficiency and reduce maintenance costs.
Why Smart Sensors?

- Standard output format ⇒ plug-and-play!
- Bus interfaces ⇒ multiple sensors, less wiring
- More functionality: self-test, diagnostics, storage of sensor ID and calibration data
- Smaller, cheaper, more reliable ...
Smart Sensor Standard

The Institute of Electrical and Electronics Engineers (IEEE) developed a smart sensor standard named **IEEE 1451.2–1997**. The standard defines:

- standard transducer interface module (STIM) that includes the sensor interface, signal conditioning and conversion, calibration, linearization, and network communication.
- enables plug and play functionality for smart sensors that connect to smart sensor networks.
- enables networks of smart sensors to communicate
A general model of a smart sensor
Example of traditional sensor and Smart Sensor.

Traditional Sensor Systems

Sensor

Interface electronics

traditional wind sensor
Smart Sensors

- Sensor + Interface electronics in one package
- Robust microprocessor compatible interface
Strange Sensors

♦ 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
New Challenges

- Designing ultra-low-power autonomous and biomedical sensors ⇒ dynamic techniques
- Designing smart sensors (e.g. temp sensors) in nanometer CMOS ⇒ time-domain signal processing
- Using dynamic techniques in other analog systems e.g. amplifiers & ADCs
- Designing smart sensors based on new types of sensors e.g. SPADs and thermal diffusivity sensors.
Conclusions

- Silicon IC technology enables low-cost production of smart sensors: sensors, actuators and interface electronics on a single chip
- Trend towards intelligent networked devices
- Promises cost reduction and functionality
- Smart sensor design is challenging!
References (1)

- **Silicon sensors:**

- **Smart sensors:**

- **Calibration:**

- **Calibration of smart sensors:**