Literature


Process Measurement Engineering

1. Introduction to Process Measurement Engineering
2. Fundamentals
3. Sensors
4. Amplification and Analog to Digital Converters
5. Data Transmission and Data Systems
Definition of Process Measurement Engineering

• What is process measurement engineering?

• What is the difference in comparison to scientific measurement engineering?

• What are the requirements for process measurement instrumentation?
Scientific measurement technology

- Measurements in order to validate scientific theories
  - Test for all scientific theories
  - Measurements may take years
    - Neutrino observatories measure continuously

History:
- 1930: Pauli postulates an “invisible” particle: neutrino (conservation of energy and momentum in beta decay)
- 1956: First neutrinos detected (Nobel prize 1995, Frederick Reines)

- Equipment may be large (e.g. DESY)
- Experiments may involve many scientists
- Automation is not required
Example: Super Kamiokande Experiment

50,000 tons of water and 11,200 photomultiplier tubes
1998: first experimental observation supporting the theory that the neutrino has non-zero mass
IceCube South Pole Neutrino Observatory

IceCube Laboratory
Data is collected here and sent by satellite to the data warehouse at UW–Madison

IceTop
50 m

1450 m

Digital Optical Module (DOM)
5,160 DOMs deployed in the ice

2450 m

86 strings of DOMs, set 125 meters apart

Amundsen–Scott South Pole Station, Antarctica
A National Science Foundation-managed research facility

DeepCore

DOMs are 17 meters apart

60 DOMs on each string

Antarctic bedrock
Example: DESY in Hamburg
HERA length: 6.3 km
Magnetic fields: 4.7 Tesla
Temperature of superconducting magnets: 4.4 K

Protons and electrons almost at the speed of light:
47000 revolutions per second
Free Electron Laser at DESY (XFEL)

Total length: 3.4 km, Wavelength: 0.6-6 nm
19 April 2017: Accelerator operational
Process Instrumentation
Chemical Process

Source: Siemens process instrumentation and analytics
Process Measurement Technology

- Measurements are performed in order to enable or optimize a process
  - Qualitative and quantitative measurements of matter (gas, liquid, solid):
    - Analysis of species: atoms, molecules, solids
    - Quantification (e.g. mass, concentration)
  - Quantitative Measurement of physical quantities (e.g.: energy, temperature, charge)
  - Measurements within automated (industrial) processes
  - Monitoring and surveillance
Requirements for process measurement techniques (I)

• Measurements should be performed automatically
• Measurements should be performed within short periods of time
• The process should not be influenced
• Goals for the accuracy (trueness) and precision are strongly dependent on the process
• Operational availability and reliability must be high
• Amount of maintenance should be low
Requirements for process measurement techniques (II)

- Systems should be rugged because they are often mounted directly at the production line
  - Varying temperatures
  - Dust
  - Vibrations
  - Electromagnetic interference

- Systems have to be stable over long periods of time (no aging of the systems)
Instrumentation of Processes: Classical Instrumentation
**Process Automation**

### Parallel Measurement/Control

- System 1
- System 2
- System 3
- System 4

- $T$
- $P$
- Flow

- Composition

- Complex control not possible

### Central Measurement/Control

- Central Computer

- Process

- Failure of central computer causes complete stop of process

- Solution:
  - Backup system
  - Distributed process automation
Distributed Process Automation

Management and Coordination Level

Process Level:
- Measure
- Control
- Monitoring

SPC - Sub Process Computer

MPC - Main Process Computer

R - Router

AU - Automation Unit

AU_1, AU_2, ..., AU_n - Automation Units

R_1, R_2, ..., R_n - Routers

SPC_1, SPC_2 - Sub Process Computers

LAN - Local Area Network

WAN - Wide Area Network

Sub process 1

Sub process 2