PAST PRESENT & FUTURE TRENDS IN INDUSTRIAL AUTOMATION

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ANNA UNIVERSITY
- DATA ACQUISITION SYSTEM (DAS)
- SUPERVISORY CONTROL SYSTEM (SC)
- SCADA
- DIRECT DIGITAL CONTROL SYSTEM (DDC)
- DISTRIBUTED CONTROL SYSTEM (DCS)
- PROGRAMMABLE LOGIC CONTROLLER (PLC)
- HART
- FIELD BUS
MOTIVATION

- Why is a Control Necessary?
- Control Objectives
  - Personnel Safety
  - Equipment Protection
  - Environmental Protection
  - Smooth operation
  - Product quality
  - Profit

Case- I = Fin = Fout
Case-II = Fin > Fout
Case-III = Fin < Fout

Note: Constant Outflow
Thyristor Power Controller

FIELD

DATA ACQUISITION SYSTEM

CONTROL ROOM

Computer (DAS)

DAQ

Analog Controller

Analog Controller

PV1

SP1

PV2

SP2
Thyristor Power Controller

Field

Direct Digital Control

Control Room

Computer (DDC)

DAQ

AI

AO

I/P

TT

LT

SP1

SP2
DISTRIBUTED CONTROL SYSTEM

- A system of dividing plant or process control into several areas of responsibility, each managed by its own controller, with the whole system connected to form a single entity, usually by means of communication buses.
Thyristor Power Controller

DISTRIBUTED CONTROL SYSTEM

I/P

TT

LT

Operator Station

Operator Station

MICROPROCESSOR BASED CONTROLLER

AI  AO

NI

NI

MICROPROCESSOR BASED CONTROLLER

AO  AI
BATCH PROCESS

Ladder Logic Programming

ON/OFF Valve

A+B → C

ON/OFF Valve

Programmable Logic Controller

Digital Inputs

Thyristor Power Controller

ON/OFF Valve

BATCH PROCESS

Ladder Logic Programming

Programmable Logic Controller

Digital Inputs

Thyristor Power Controller
HART (Highway Addressable Remote Transducer)


- HART Analog Communications - use industry standard 4-20 mA signal only – only one parameter (Process Variable or Controller Output) – communicated to the host system.

- HART Digital Communications – Added information (Device Status and Diagnostic Alerts; Process Variables and Units; Loop Current and % Range, Basic Configuration Parameters, Manufacturer and Device Tag etc.,) – 35-40 information items.
- HART Digital Communications – Low level modulation superimposed on the standard 4-20 mA current loop – BELL 202 MODEM- Frequency Shift Keying (FSK) – Logic 1 – 1200 Hz and Logic 0 – 2200 Hz (with an amplitude of −0.5mA to +0.5mA) – Device configuration, non-real-time diagnostics, and status monitoring.

- Two-way communication.

- Master/Slave Protocol (Message Rate −2)

- HART burst mode communications (Message Rate− 3)

- Multivariable Instruments.

- HART Multidrop Mode.

- Interoperability.
Use multidrop connection for supervisory control installations that are widely spaced, such as pipelines, custody transfer stations, and tank farms.

Note: Instrument power is provided by an interface or external power source that is not shown.

Figure 3: Multidrop Mode of Operation
Figure 13: Tri-Loop Module

- Field Terminals
- Rail-Mounted Tri-Loop Module
- 4-20 mA Signals for Secondary Variables
- Control System
- **HART Commands**
  - **Universal Commands (Primary Variable and Units; Current output and % of Range; Manufacturer and device type)**
  - **Common Practice Commands (Device range values; filter time constant; set fixed output current; transfer function (square root/linear)- perform self test - remote calibration**
  - **Device Specific Commands (PID enable; PID setpoint; start, stop or clear totalizer; user units, local display information; travel limits; valve setpoint)**
Benefits of HART Communication

- Improved Plant operation
  - Commissioning and Installation
  - Plant operation and improved quality
  - Maintenance
- Operational Flexibility
- Instrument Investment Protection
- Digital Communication

Control in Field Devices

Hand-Held Communicator
- Network System: HART
- Technology Developer: Rosemount
- Year Introduced: 1989
- Openness: Open standard, 600+ products, 130+ suppliers
- Network Topology: point-to-point; digital Multidrop
- Physical media: Twisted pair
- Maximum devices (2 masters, 1 slave); 17 multidrop (2 masters, 15 slaves)
- Maximum Distance: 3,000m
- Communication methods: Master/Slave; broadcast
- Transmission properties: 2-4 updates/sec continuous 4-20mA current loop
- Data Transfer size: Data byte Structure: 11 bits, 15-50 bytes
Figure 18: Smart Transmitter with PID
FOUNDATION FIELDBUS

- All digital serial two-way communication system – interconnects field equipments (sensors, actuators and controllers) – architecture for building interoperable distributed real time control systems.
- Multidrop wiring (32 devices on a single pair of wires (called a segment))

- Multivariable Instruments (Multiple variables from one field device)

- Two-way communication

- New types of information

- Control in the field
Interoperability: Device from different suppliers can be communicate with each other and perform their function in multi-vendor environments. (standardize communication protocol from Physical layer through Application Layer)

Interchangeability: Device from different suppliers can be functionally interchanged by providing the same functionality for the same type of devices. (Standardize various function blocks)

What user wants is to provide interoperability and the same basic functionality for the same type of devices and room for innovation by suppliers for additional unique functionality (Provide a common way to describe/understand suppliers specific features (DDL)).
- Foundation fieldbus communications model
  - The Physical Layer
  - Data Link Layer and Application Layers
  - The User Layer
- Physical Layer: Translating messages into Physical signals on the wire—and vice versa
- Physical Layer: Provides the common Electrical Interface for all foundation fieldbus devices. (H1 segments
  - Power supply 9-32 Volts DC Power and 15-20 mA of current per device – communication rate
  - 31.25 kbaud – 32 devices per segment; upto 240 devices total with repeaters.
Data link and Application layers: Control transmission of data on the fieldbus.

Standard way of packaging the data as well as managing the schedule for communication and function-block execution.

User Layer: contains transducer block, resource block and function blocks that describe and execute device capabilities such as control and diagnostics. Device descriptions enable the host system to interact with and understand these blocks without custom programming.
FOUNDATION FIELD BUS BENEFITS
<table>
<thead>
<tr>
<th>Function Block Name</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Input</td>
<td>Al</td>
</tr>
<tr>
<td>Analog Output</td>
<td>AO</td>
</tr>
<tr>
<td>Bias</td>
<td>B</td>
</tr>
<tr>
<td>Control Selector</td>
<td>CS</td>
</tr>
<tr>
<td>Discrete Input</td>
<td>DI</td>
</tr>
<tr>
<td>Discrete Output</td>
<td>DO</td>
</tr>
<tr>
<td>Manual Loader</td>
<td>ML</td>
</tr>
<tr>
<td>Proportional/Derivative</td>
<td>PD</td>
</tr>
<tr>
<td>Proportional/Integral/Derivative</td>
<td>PID</td>
</tr>
<tr>
<td>Ratio</td>
<td>RA</td>
</tr>
</tbody>
</table>

Table 5 – The 10 basic standard function blocks defined by FOUNDATION Fieldbus.

Figure 4 – A Basic Control Loop Using AI, PID, and AO Function Blocks.
- Application clock (Real time clock)
  - Process Control is time dependent
  - System management function – periodically broadcast the time to all devices. Each device uses an internal clock to keep time between these synchronization broadcast - all devices have the same real-time, enabling deterministic communications and control execution
  - Alarms and events are time stamped at the device where they occur.

- Parameter status
  - Status associated with every parameter (quality of the data)
    - Good, bad or uncertain
- **Scheduled Communications**
  - All devices and function blocks on a FF segment execute and communicate - process control information - on a regular, repeating cycle.
  - Timing-master schedule in a link active scheduler - residing in the host system or one of the devices on the segment. (link active scheduler function maintains the central, deterministic schedule for the communication between devices on a segment. Communication reliability - by compelling each device to transmit cyclic data when it is scheduled to do so. (if the LAS fails, then backup LAS in another device or host system component takes over as master scheduler)
  - Cyclic communications use publisher/subscriber method
  - Cyclic communications are Deterministic

- **Unscheduled Communication (or) acyclic communication**
  (flexible timing - lower priority on the segment than scheduled control loop related communication)
  - Configuration information
  - Alarm and trend data
  - Diagnostic and status information
Benefits of Fieldbus

- System can be built from devices manufactured by different vendors
- No single company controls the evolution of the standard
- Interoperability
- Reduced Cost
  - Less wiring installation and maintenance cost because of multi-drop
  - Better diagnostics through software
  - Control distributed in the field
- More data available from the devices
  - Diagnostic Data
  - Multiple variables
- **Network System:** FIELDBUS
- **Technology Developer:** Fieldbus Foundation (H1/HSE)
- **Year Introduced:** 1995/2000
- **Openness:** Multiple vendors
- **Network Topology:** star, bus
- **Physical media:** Twisted pair, fiber
- **Maximum devices:** 32 devices/ segment
- **Maximum Distance:** 1,900 at 31.25 Kbps
- **Communication methods:** Peer-to-peer
- **Transmission properties:** 31.25Kbps
- **Data Transfer size:** 128 bytes