Operation

Benefits

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Operation Benefits Topics

- Higher performance control
- Early process warning from device alerts
- Increased availability
- High fidelity
High Performance

Digital Closed Loop Control
Some “Digital Control Systems” Aren’t

<table>
<thead>
<tr>
<th></th>
<th>Hardwired</th>
<th>Fieldbus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Process</td>
<td>Discrete</td>
</tr>
<tr>
<td>Real-time control</td>
<td>Analog (4-20 mA)</td>
<td>Binary (on/off)</td>
</tr>
<tr>
<td>Device management</td>
<td>Digital (HART and proprietary)</td>
<td>None</td>
</tr>
</tbody>
</table>

- If it’s not fieldbus, it’s not a digital control system

Hardwired: Digital → Analog → Digital → Analog → Digital
Fieldbus: Digital → Digital → Digital → Digital
End-to-End, Fieldbus Control is Faster

- Analog Control
  - AI scan, controller, and AO scan asynchronous
    - A 250 ms controller cycle does not mean 250 ms control response period

- Fieldbus Control
  - AI scan, controller, and AO scan asynchronous

> 2 x Controller Cycle
Scheduled Execution and Punctual Communication

- FF communication and execution is synchronized
  - Shortest possible dead-time
  - Precisely periodic sampling: no jitter

- AI/AO and other buses are asynchronous
  - Longer dead-time
  - Sampling jitter

Designed for process control
What is the Significance of Control Response Period?

- It all adds up to process variability
  - Multiple loops per processing units
  - Multiple processing units per plant
- Translates into better quality and throughput
- Leading process licensors specify 300 ms control loops
Advanced: Time Division Multiplexing

- FOUNDATION fieldbus
  - Scheduling
    - Synchronized
    - Precisely periodic (isochronous)

- Other buses
  - "Free running"
  - Longer time
  - Jitter = sampling period not constant

\[
OUT = P \times \left( e + \frac{1}{I} \int e \, dt - D \times \frac{dPV}{dt} \right)
\]

\[e = PV - SP\]
\[dt = \text{sampling period must be constant}\]
Easy: Scheduling is Automatic

**Schedule Viewer CTRL-01/IO1/C05/P01**

- **Block Execution**
- **Scheduled communications**

<table>
<thead>
<tr>
<th>Module</th>
<th>Block (Device/Block Tag)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIC-401</td>
<td>AI1(TT-401/BFFAI_RMT5)</td>
</tr>
<tr>
<td></td>
<td>AI2(TT-401-AFFAI_RMT1)</td>
</tr>
<tr>
<td></td>
<td>ISEL1(CTLR-01/IO1/C05/P01/FB006000)</td>
</tr>
<tr>
<td></td>
<td>PID1(CTLR-01/IO1/C05/P01/FB005000)</td>
</tr>
<tr>
<td></td>
<td>AO1(TV-401/FFAO_RMT1)</td>
</tr>
<tr>
<td>PIC-201</td>
<td>AI1(PT-201/FFFAI_RMT8)</td>
</tr>
<tr>
<td></td>
<td>PID1(PV-201/FFPID_RMT3)</td>
</tr>
<tr>
<td></td>
<td>AO1(PV-201/FFAO_RMT4)</td>
</tr>
</tbody>
</table>

**Schedule is automatically created**

**P01 Properties**

- **Object type**: Fieldbus Port
- **Modified**: May 23 2007 12:21:10 PM
- **Modified by**: ADMINISTRATOR
- **Enabled**: Yes
- **Description**: Fieldbus Interface Port

- **Schedule Macrocycle**
  - **Request macrocycle**: 150 ms
  - **Calculated macrocycle (ms)**: 150 ms, 250 ms, 500 ms, 1 sec, 2 sec, 5 sec
Fast
Below 300 ms Loops Now Possible

- Fast devices
  - Fast blocks
    - < 30 ms
  - Fast links
    - << 30 ms

- Control in the Field
  - Extensive block library
    - ARTH, ISEL, CS...

<table>
<thead>
<tr>
<th></th>
<th>Current Generation</th>
<th>First Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pressure</td>
<td>Positioner</td>
</tr>
<tr>
<td>AI</td>
<td>20 ms</td>
<td></td>
</tr>
<tr>
<td>PID</td>
<td>30 ms</td>
<td></td>
</tr>
<tr>
<td>AO</td>
<td>25 ms</td>
<td></td>
</tr>
<tr>
<td>Link</td>
<td>30 ms</td>
<td></td>
</tr>
</tbody>
</table>

250 ms

60 ms (< 30%)
ISC Study on Control in the Field

- “Control in the field: analysis of performance benefits” study from ISC (industrial systems and control)
- 40-60% faster settling time on setpoint change
- 30-50% better disturbance rejection
- Most significant for fast processes (flow and pressure)
Easy Operation - PID Auto Tuning for CIF

- On-demand or adaptive tuning of PID
- Recommends tuning based on test
- Loop remains under control during test

Control-in-the-field does not mean just “simple” PID
Early Warning

Act before process is affected
Integrated Control System

- Engineering station
  - System configuration
  - FF device commissioning
  - Device configuration

- Operator station
  - Process operation
  - Process alarms
  - Critical device failure diagnostics

- Maintenance station
  - Device management
  - Process visibility

Plus:
- Device Configuration
- Device Diagnostics
- Process visibility

Freedom to Choose. Power to Integrate.
Smart Diagnostics - Integrated Device Diagnostics

- Normal operation...
- Device failure...
- Faceplate...
  - No device configuration by operator

Detailed diagnostics in two clicks
Help on the third
On/Off Valves

- Fieldbus does discrete too
- One pair of wires for multiple on/off valves
- One pair of wires for solenoid and limit switches
- Diagnostics
- HART not applicable
Real-time Status

If its not the process, don’t trip unnecessarily
Digital All the Way - Digital Closed Loop Control

Speed
- 25 times faster than hybrids of analog/digital
- 250 ms loops possible
- Real-time value and status

Only fieldbus eliminates the analog signal

Validity: Good/Bad/Uncertain

Status Propagation (CIF & CIC)
- Validated information
  - Quality and limits
- Windup protection
- Bumpless transfer for valves
- Fault-state for valves
- etc.

Designed for process control

Initiate Fault-State Command

Limited: High/Low Bumpless Transfer Windup Protection Fault-state Status
Process Variable Validity

- **Hardwired**
  - Device drives current <4 mA or >20 mA on device failure
    - Looks like process problem
  - PID counteracts thus tripping the loop
  - Operator cannot tell the difference between a process alarm and a device alarm

- **Fieldbus**
  - Device health indicated by associated status
  - Controller holds last position on device failure
    - Shutdown is optional
  - Operator can easily distinguish process problem from a device problem
Valve and Positioner

- Actual position transmitter feedback transmission on the same two wires
  - Further reduced wiring
  - No AI card
  - More than just value: status
- Software limit switches
  - No DI cards
  - No extra wiring
- Easy to add feedback as an afterthought
- Bumpless transfer on local hand operation
  - Smoother operation
- Bumpless firmware download
  - Upgrade while process is running, without replacing circuit board

Continuous, real-time, actual position feedback for every control valve
Easy Operation - Status in Historian

- Status logged and shown next to value and color codes trend
Fidelity

Freedom to Choose. Power to Integrate.
Digital Fidelity - Better Accuracy

Hardwired
- Accuracy lost in signal conversations:
  - Digital to analog
  - Analog to digital
- Accuracy lost in current calibration differences

Fieldbus
- Measurements are not distorted
- Particularly important:
  - Tank gauging
  - Batching
Easier and Safer: High Signal Integrity

Hardwired
- Analog gets distorted
  - Increased resistance limits current
  - Ground loop offsets current
- ‘On-scale” distortion cannot be detected

Fieldbus
- Digital signal does not get "limited"
- Any distortion of a digital process variable is alerted

Marshalling

Resistance = Voltage
Drop = Limited Current

Leakage = Ground Loop = More Current

Freedom to Choose. Power to Integrate.
Easier and Safer
- Real Number Engineering Unit

- Measure to full sensor limits
  - Reading not saturated at 100%
  - Better understanding during abnormal conditions
Fieldbus Operational Benefits Summary

- Higher performance control
  - Faster than analog
- Early process warning from device alerts
  - Diagnostics in operator console
  - Diagnostics from discrete devices
- Increased availability
  - Real-time status
- High fidelity
  - High accuracy
  - No range mismatch