Operation

Benefits
Operation Benefits Topics

- Higher performance control
- Early process warning from device alerts
- Increased availability
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>Real-time process control</td>
<td>Analog (4-20 mA)</td>
<td>Digital</td>
</tr>
<tr>
<td>Device management</td>
<td>Digital (HART and proprietary)</td>
<td>Digital</td>
</tr>
</tbody>
</table>

- If it’s not fieldbus, it’s not digital control system
End-to-End, Fieldbus Control is Faster

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

- 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

<table>
<thead>
<tr>
<th>Controller</th>
<th>PID</th>
<th>PID</th>
<th>PID</th>
<th>PID</th>
<th>PID</th>
<th>PID</th>
<th>PID</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Transmitter</td>
<td>AI</td>
<td>AI</td>
<td>AI</td>
<td>AI</td>
<td>AI</td>
<td>AI</td>
<td>AI</td>
<td>AI</td>
</tr>
<tr>
<td>Valve</td>
<td>AO</td>
<td>AO</td>
<td>AO</td>
<td>AO</td>
<td>AO</td>
<td>AO</td>
<td>AO</td>
<td>AO</td>
</tr>
</tbody>
</table>

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

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

\[
e = PV-SP
\]
\[
dt = \text{sampling period must be constant}
\]

Designed for process control
Easy: Scheduling is Automatic

<table>
<thead>
<tr>
<th>Module</th>
<th>Block Appendix</th>
<th>Block Tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIC-431</td>
<td>A1(TT-431-E/FFA_RMT1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A2(TT-431-E/FFA_RMT2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ISEL1CTRL-01/C01/C05/P01/FB000030D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PID CTRL-01/C01/C05/P01/FB0000300</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AO1(TV-431/FAC_RMT1)</td>
<td></td>
</tr>
<tr>
<td>PIC-231</td>
<td>A1(PT-231-E/FFA_RMT1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PID(FV-231/EFFP_RMT3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AO1(FV-231/EFFP_RMT4)</td>
<td></td>
</tr>
</tbody>
</table>

Schedule is automatically created.
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>Current Generation</th>
<th>First Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>Positioner</td>
</tr>
<tr>
<td>AI</td>
<td>20 ms</td>
</tr>
<tr>
<td>PID</td>
<td>30 ms</td>
</tr>
<tr>
<td>AO</td>
<td>25 ms</td>
</tr>
<tr>
<td>Link</td>
<td>30 ms</td>
</tr>
</tbody>
</table>
ISC Study on Control in the Field

- “Control in the field: analysis of performance benefits” study from ISC (industrial systems and control)
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
Smart Diagnostics - Integrated Device Diagnostics

- Normal operation...
- Device failure...
- Faceplate...
- Diagnostics
  - 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
Status

If it's 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

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

Only fieldbus eliminates the analog signal
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

- Accurate measurements are not distorted by signal conversations:
  - Digital to analog
  - Analog to digital
- Particularly important in some flow and level applications where small amounts correspond to a lot of money
Easier and Safer: High Signal Integrity

- Digital signal does not get "limited"
  - If 20 mA becomes 18 mA you won't know
    - Increase in resistance due to terminal corrosion
  - If 16 mA becomes 18 mA you won't know
    - Ground loop due to inadvertent ground leakage

- Digital signal distortion does not go undetected
  - It is not possible to detect distortions in an analog signal

Any distortion of a digital process variable is alerted

Resistance = Voltage Drop = Limited Current

Analog PV is distorted

Leakage = Ground Loop = More Current
Easier and Safer
- Real Number Engineering Unit

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

20 mA / 10 ft
20 mA / 10 ft

4 mA
20 mA
10 ft
13 ft

0
Transmitter
CPU
D/A

Normal Range

Digital

Range

AI
A/D

Digital

CTRL
CPU

4-20 mA

Lower Limit

Upper Limit