Introduction to Process Control & Automation

University of Nottingham – Andrew Mieleniewski
Industrial Food Manufacture – Process Control & Automation

- Agenda

1. Introductions
2. Introduction to batch process control
3. Control system hardware (overview only)
4. System software terminology and concepts
Why Automate?
Automation is complex, expensive, and can be full of jargon and acronyms!

So why do we do it?

Three key points:

- Improvements in quality (improved repeatability and increased precision)
- Reduction in human intervention (redeploy personnel or allow more to be done for similar manual input).
- Because the underlying technology requires it (speed of response or complexity difficult for a human to provide).
Example – Storage Tank Farm Valve Matrix
Example – Storage Tank Farm Valve Matrix
Matrix Valve Actuator

Digital control signals
- Open feedback signal
- Closed feedback signal
- Energise signal

Solenoid Valve (small electrically operated valve)

Compressed Air

Control Top

Actuator

Air-to-open
Spring-to-close

Open Position

Closed Position

Open feedback signal
Closed feedback signal
Energise signal
System Hardware

- PLC (Programmable Logic Controllers)
- HMI (Human Machine Interface)
**PLC Based Control System**

- **Food & Drink Automation**
  - Mainly batch sequence processing
  - Using Programmable Logic Controllers (PLC)

- **Modular Rack/chassis**
  - Power Supply Unit (PSU)

- **Central Processing Unit (CPU)**

- **Network Modules (Ethernet)**
  - Terminals and other systems
  - Fieldbus (smart instruments)

- **Digital Input/Output (I/O)**

- **Analogue I/O**
  - 4-20mA loops
  - HART (Highway Addressable Remote Transducers) Instruments – additional digital information

- **Remote I/O**

- **Field Item Interface**
  - Valve actuators
  - Motor Starters

- **Control Panels**
PLC Hardware

- PLC are industrialised
  - Rugged & reliable
  - Handle high temperatures, humidity, & electrical noise
  - mean-times-between-failures are two orders of magnitude higher than that of a PC

- PLCs are proprietary closed architecture systems
  - Parts and software from one manufacturer cannot be used with parts of another
  - Once you have made your initial choice you will be locked into your suppliers range for future upgrades and expansions
  - The two big vendors are Siemens and Rockwell

Siemens – S7 PLC

Rockwell Allen Bradley – ControlLogix PLC
Cable Management
Control Panels
Valves & Instrumentation
# HMI (Human Machine Interface)

<table>
<thead>
<tr>
<th>HMI Type</th>
<th>Hardware Platform</th>
<th>Functionality</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Batch Initiation</td>
</tr>
<tr>
<td>MES (Management Execution System)</td>
<td>General Business PC</td>
<td>-</td>
</tr>
<tr>
<td>SCADA (Supervisory Control and Data Acquisition)</td>
<td>Dedicated PC</td>
<td>Yes</td>
</tr>
<tr>
<td>HMI Graphic Terminal</td>
<td>PLC Proprietary</td>
<td>Yes</td>
</tr>
<tr>
<td>Lamps &amp; push buttons</td>
<td>Component</td>
<td>Yes</td>
</tr>
</tbody>
</table>

1. Lamps & push buttons
2. HMI Graphic Terminal
3. SCADA (Supervisory Control and Data Acquisition)
4. MES (Management Execution System)
System Software

- Ladder Logic
- System Size
- Control Loops
- Software Development
- State of the Art Systems
PLC Software – Ladder logic

Ladder logic

- Replicates relay logic
- Logic conditions on left
- Outputs on right
- Rungs processed sequentially
- Scanned many times per second
System Size

Hardware Setup
- Proportional to I/O points (# Racks → # Chassis)
- Each valve could have 3 I/O points
- Large systems can have 1000’s of I/O points

Software
- Proportional to I/O
- Process complexity is a factor
Feedback control loops are often used and have three elements:

- **Process Variable (PV)** – measurement of the parameter to be controlled
- **Set Point (SP)** – required or target value of the process variable
- **Output (OP)** – output from the control loop

Common feedback loop controller is a **PID controller**.

- **Proportional (P)** – the output value is changed in proportion to the size of the error
- **Integral (I)** – the output value is changed in proportion to the duration of the error
- **Derivative (D)** – the output value is changed in proportion to the rate of change of the error.

The ratio of each of the three terms can be varied thereby tuning the loop to give good control.

PID controllers used to be separate electronic units but now usually algorithms built into the PLC software.
<table>
<thead>
<tr>
<th>User</th>
<th>Design Engineer</th>
<th>Software Developer</th>
<th>Notes</th>
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<tbody>
<tr>
<td>URS (User Requirement Specification)</td>
<td></td>
<td></td>
<td>Defines automation requirements from users point of view</td>
</tr>
<tr>
<td>FDS (Functional Design Specification)</td>
<td></td>
<td></td>
<td>Detailed definition of how the automation system works</td>
</tr>
<tr>
<td>Internal Testing / software simulation</td>
<td>Software Development</td>
<td></td>
<td>Development structured by in-house and/or customer coding standards</td>
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<tr>
<td>Customer Acceptance Testing (CAT)</td>
<td></td>
<td></td>
<td>In-house testing of software code and function – most bugs removed at this point</td>
</tr>
<tr>
<td>Field Testing / Commissioning</td>
<td></td>
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<td>Functional demonstration of system requirements</td>
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<td>Parameter setting, fine tuning, and hopefully only minor changes to support process commissioning</td>
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State Of The Art Systems

1. Process Control

2. Configurable recipe management (more easily changed)

3. Supervision, Control, & Data Acquisition (SCADA)
   - Parameterised software development - No ladder logic coding

4. Mobile data monitoring

5. Management Information & Execution (MES/MIS)
   - Run on multiple PLC hardware platforms

In one system

For example – brewmaxx by ProLeit

State Of The Art Systems

Rockwell Automation

Mitsubishi Electric

Siemens
Questions?

T: +44 1283 566661
E: sales@briggsplc.co.uk
W: www.briggsplc.com

Briggs of Burton PLC, Briggs House, Derby Street, Burton on Trent, Staffordshire, DE14 2LH, United Kingdom