



Technology Training that Works

Fundamentals of Industrial Automation

Contents

Prelims		1
1	Introduction	1
1.1	Workshop outline	1
1.2	Introduction	2
1.3	Industrial automation	2
1.4	Training requirements for industrial automation training	4
1.5	History of industrial automation	4
1.5	Structure of the manual	5
2	Best Practice in Control, Instrumentation Standards, Documents and Drawings	7
2.1	Drawing office operating standards	7
2.2	Process Diagrams	18
2.3	Instrumentation Documentation	27
2.4	Vendor	55
3	Instrumentation	67
3.1	The definition of transducers and sensors	67
3.2	Listing of common measured variables	68
3.3	The common characteristics of transducers	69
3.4	Sensor dynamics	71
3.5	Selection of sensing devices	71
3.6	Temperature sensors	71
3.7	Pressure transmitters	79
3.8	Flow meters	88
3.9	Level transmitters	96
3.10	The spectrum of user models in measuring transducers	98
3.11	Instrumentation and transducer considerations	99
3.12	Selection criteria and considerations	102
3.13	Introduction to the smart transmitter	104
4	Basic Principles of Control Valves and Actuators	107
4.1	An overview of eight of the most basic types of control valves	107
4.2	Control valve gain, characteristics, distortion And rangeability	125
4.3	Control valve actuators	129
4.4	Control valve positioners	134
4.5	Valve sizing	136



Technology Training that Works

5	Fundamentals of control systems	137
5.1	Objectives	137
5.2	ON-OFF control	137
5.3	Modulating control	139
5.4	Open loop control	139
5.5	Closed control loop	141
5.6	Dead time processes	145
5.7	Process responses	147
5.8	Dead zone	148
6	PLCs, PACs and SCADA Systems	149
6.1	Introduction to the PLC	149
6.2	Basic block diagram of the PLC	151
6.3	Size of the PLC system	152
6.4	Components of the PLC system	152
6.5	PLC and process interaction	154
6.6	Programmable automation controllers	157
6.7	Introduction and brief history of SCADA	162
6.8	Fundamental principles of modern SCADA systems	164
6.9	SCADA hardware	166
6.10	SCADA software	166
6.11	The SCADA software package	168
6.12	Design of the computer displays	175
6.13	Design of screens	177
6.14	Comparison of the terms SCADA, DCS, PLC and smart instruments	179
7	Process control	185
7.1	Introduction	185
7.2	Process modeling	187
7.3	Types or modes of operation process control systems	190
7.4	PID control	192
7.5	PID tuning	199
7.6	Reaction curve method (Zeiger Nichols)	201
7.7	Zeiger Nichols open loop tuning method (1)	204
7.8	Zeiger Nichols open loop method (2) using POI	205
7.9	Loop time constant (LTC) method	207
7.10	Hysteresis problems that may be encountered in open loop tuning	209
7.11	Continuous cycling method (Zeiger Nichols)	210
8	Controller Output Modes, Operating Equations, Cascade Control and Advanced Process Control	213
8.1	Controller output	213
8.2	Multiple controller output configurations	215
8.3	Saturation and non-saturation of output limits	216



Technology Training that Works

8.4	Cascade control	217
8.5	Initialization of a cascade system	219
8.6	Equations relating to controller configurations	220
8.7	Application notes on the use of equation types	223
8.8	Tuning of a cascade control loop	225
8.9	Cascade control with multiple secondaries	225
8.10	Advanced process control (APC)	226
<hr/>		
9	Introduction to Data Communications	231
<hr/>		
9.1	The open systems interconnection (OSI) model	231
<hr/>		
10	Industrial Ethernet	239
<hr/>		
10.1	10 Mbps CSMA/CD Ethernet	239
10.2	Medium access control (collisions)	243
10.3	Frame transmission	245
10.4	Frame reception	245
10.5	Frame format	246
10.6	100 Mbps Ethernet	247
10.7	Gigabit Ethernet	249
10.8	Switching technology	249
10.9	Industrial Ethernet	253
<hr/>		
11	Industrial Wireless	263
<hr/>		
11.1	Wireless Las (IEEE 802.11)	263
<hr/>		
12	Automation Networks	291
<hr/>		
12.1	Background	291
12.2	Plant automation hierarchies	293
12.3	Ethernet in field buses	294
12.4	HART	295
12.5	DeviceNet	306
12.6	Ethernet/IP	314
12.7	Profibus	319
12.8	PROFInet	330
12.9	Foundation Fieldbus	340
<hr/>		
13	OPC	349
<hr/>		
13.1	What is an OPC?	349
13.2	The problems addressed by an OPC	350
13.3	The OPC logical object model	353
13.4	Tunneling	355
<hr/>		
14	SCADA to Business Systems	357
<hr/>		
14.1	Introduction	357
14.2	Manufacturing execution systems	359



Technology Training that Works

14.3	Industry standards	370
14.4	ANSI/ISA 88 Batch Standard	370
14.5	System integration models – ANSI/ISA 95	382
15	Project motivation and benefit quantification	389
15.1	Introduction	389
15.2	Project portfolio	390
15.3	Project motivation	391
15.4	Potential benefits	391
15.5	Benefits of IT architecture components	392
15.6	Benefit quantification	393
15.7	Benefits and architectural levels	400
15.8	Extended benefit analysis	402
15.9	Benefits of an extended business care	403
15.10	Benefit examples	404
15.11	Measurement examples	408
16	Forecasts and Predictions	411
	The Future of Industrial automation	420
	Solutions for the China Challenge	424
	Appendix A	431
	Appendix B	483
	Appendix C	489
	Appendix D	535
	Appendix E	553