

ECE 528 – Understanding Power Quality

<http://www.ece.uidaho.edu/ee/power/ECE528/>

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Today...

- A very basic introduction to industrial controls
 - Basic hard-wired controls
 - Common symbols
 - Conventions
 - Some examples
 - Programmable Logic Controllers (PLCs)
 - Power quality issues

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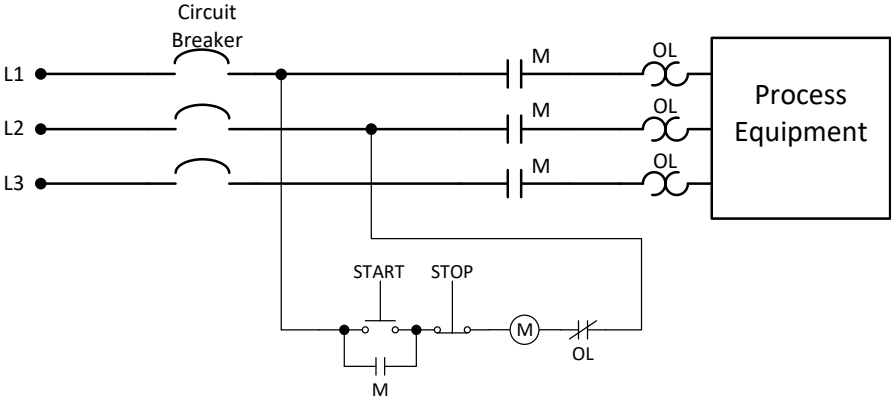
Some terms

- Process variable
 - What is measured: Temperature, flow, pressure, mass, concentration, voltage, etc.
- Set point
 - The target for the process variable
- Error
 - The difference between the set point and the value of the process variable
- Controlled output
 - What is varied, to move the process variable value toward the set point

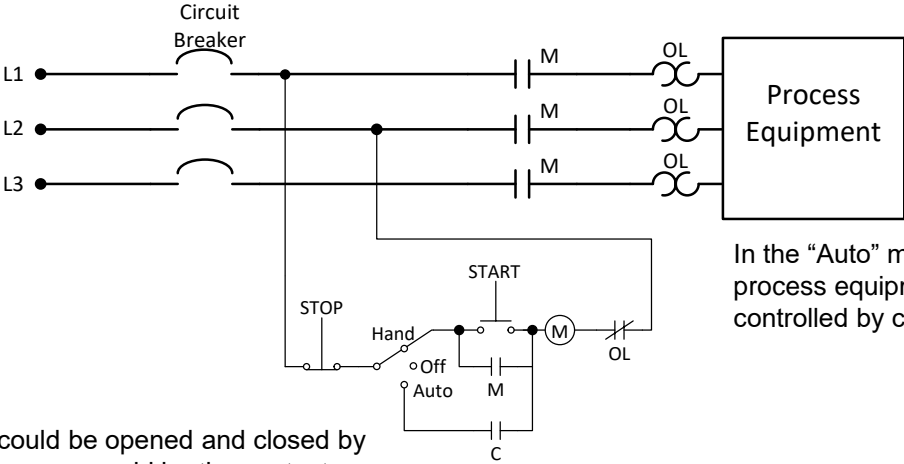
Important factors in industrial controls

- Factors affecting process control and the response of processes
 - Deadtime: the delay between a change to a control input and a detectable change in the process output
 - Gain: $\frac{\% \text{ output}}{\% \text{ input}}$ (may not be constant)
 - Inertia – mechanical, thermal
 - Changing environment
 - Changes in external processes
 - Change in process demand

A basic example – manual control



A basic example – automatic control



In the "Auto" mode, this process equipment can be controlled by contact "C".

Contact "C" could be opened and closed by another process, or could be the contacts of a temperature switch, a level switch, etc.

Common symbols – Switches

From Siemens STEP – Basics of Control Components

- See IEEE-315/ANSI Y32.2 – “Graphic Symbols for Electrical and Electronics Diagrams”

Limit Switches		Foot Switches	Pressure and Vacuum Switches		Liquid Level Switches	
Normally Open	Normally Closed	NO	NC	NO	NC	NO
Held Closed	Held Open	NC	Temperature Actuated Switches		Flow Switches (Air, Water, Etc.)	

Single Circuit		Double Circuit
NO	NC	NO & NC

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Common symbols – Coils and Contacts

From Siemens STEP – Basics of Control Components

- Energizing coils operates contacts

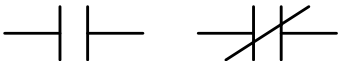
Coils
Shunt

Contacts							
Instant Operating				Timed Contacts - Contact Action Retarded After Coil Is:			
With Blowout		Without Blowout		Energized		Deenergized	
NO	NC	NO	NC	NOTC	NCTO	NOTO	NCTC

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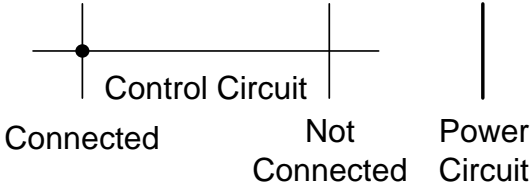
Conventions

- Normally open/normally closed
 - Contacts are shown in their de-energized state



- When their associated coil is energized, the contacts change state

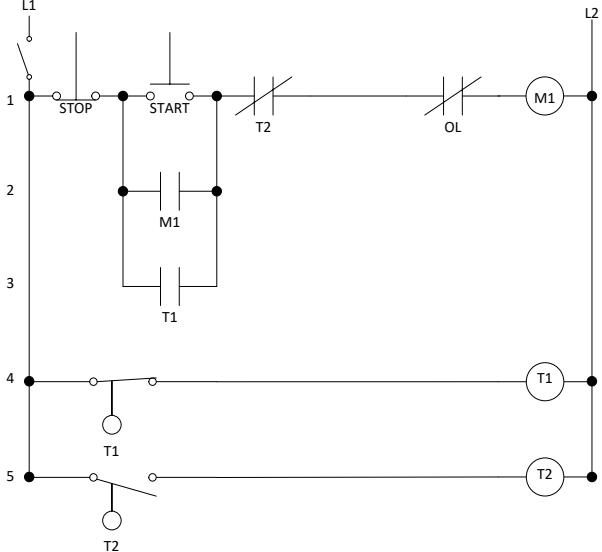
- Line styles



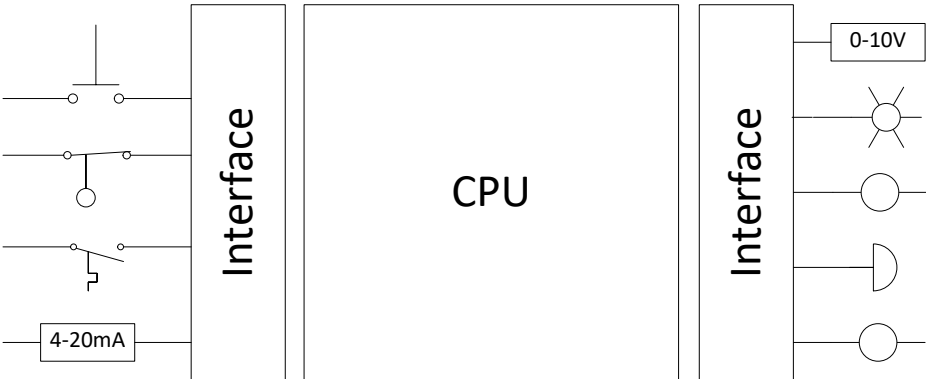
Ladder diagrams

Ladder Diagrams

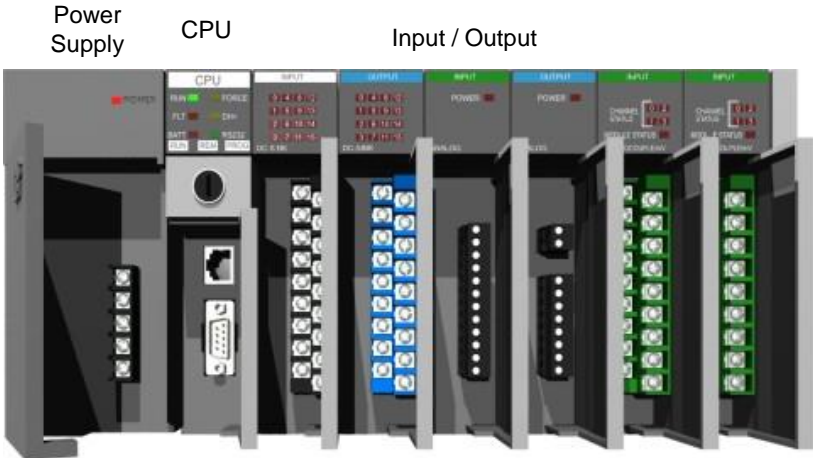
- Control voltage is connected to L1 and L2
- Common Control voltages
 - 120Vac
 - 24Vdc
 - Line-voltage



Programmable Logic Controllers



A Programmable Logic Controller



Picture from plcdev.com

Advantages of PLCs

- Allows quick changes to:
 - Setpoints
 - Process behavior
 - Relationships between inputs and outputs
- Allows for very complex process control
- Human interfaces can quickly be set up to provide process control functions and repurposed as process changes
- Physical control relays are not needed – PLC can provide internal contacts

Control system vulnerabilities

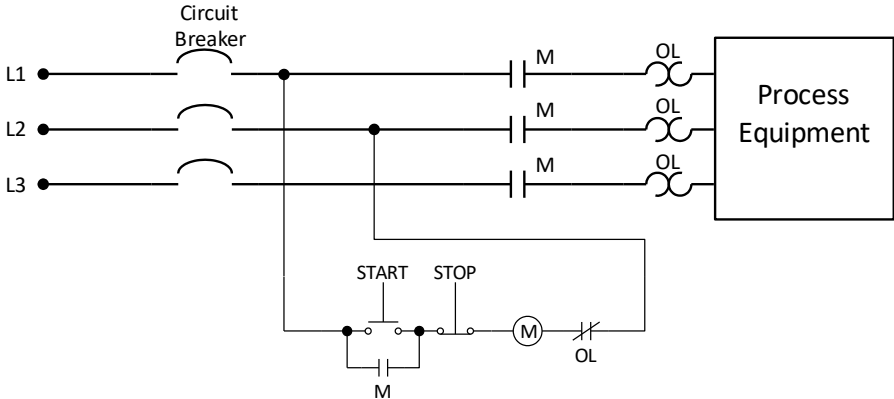
- Control system – PLCs, relays, and contactors can be impacted by power quality disturbances
- Not all components are affected equally; some devices may trip during a particular voltage sag while other devices continue to operate normally.
- The result is loss of process control.

Some voltage sag thresholds

Equipment	Upper Range	Average	Lower Range
PLC	20ms, 75%	260ms, 60%	620ms, 45%
PCL I/O card	20ms, 80%	40ms, 55%	40ms, 30%
5hp AC drive	30ms, 80%	50ms, 75%	80ms, 60%
ac control relay	10ms, 75%	20ms, 65%	30ms, 60%
Motor starter	20ms, 60%	50ms, 50%	80ms, 40%
PC	30ms, 80%	50ms, 60%	70ms, 50%

PQ is not always considered in the design

- Control system may direct process to operate when supply voltage is unacceptable



PQ may be suspected in process problems

- Hunting processes
- Process control problems
- Equipment failures
- Unexpected shutdowns of drives

Next time...

- Incorporating Power Quality into control system design
- Reminder:
 - Download and read Siemens STEP documents linked to on the class PQ links page
- 2017 Engineering Internships: Electrical, Civil, Mechanical
 - See “careers” on idahopower.com website
 - Deadline to apply is 11/21/16