University of Idaho
College of Engineering

ECE 528 – Understanding Power Quality

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

Paul Ortmann
portmann@uidaho.edu
208-733-7972 (voice)

Lecture 36

Today

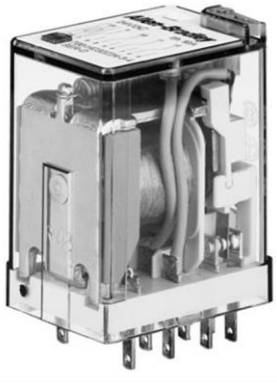
- Power quality and industrial controls
  - Identifying vulnerabilities
  - Protecting components
  - Keeping control systems operating
  - Making the control system "PQ aware"

Power Quality objectives for control systems

- Reduce vulnerability of processes to power quality disturbances
  - Protect control system components
  - Keep control system operational during power quality disturbances
  - Prevent control system from operating equipment in unsatisfactory conditions
  - Let control system respond to PQ disturbances

First steps – identify vulnerabilities

- If available – portable sag generators can help identify "weak links"
- Use databases of equipment vulnerability (EPRI "PQ Investigator")
- Common vulnerabilities
  - Ice cube relays are notoriously vulnerable to voltage sags
  - Other AC contactors may be similarly vulnerable
  - PLCs may trip causing a loss of process control



Picture from ab.com

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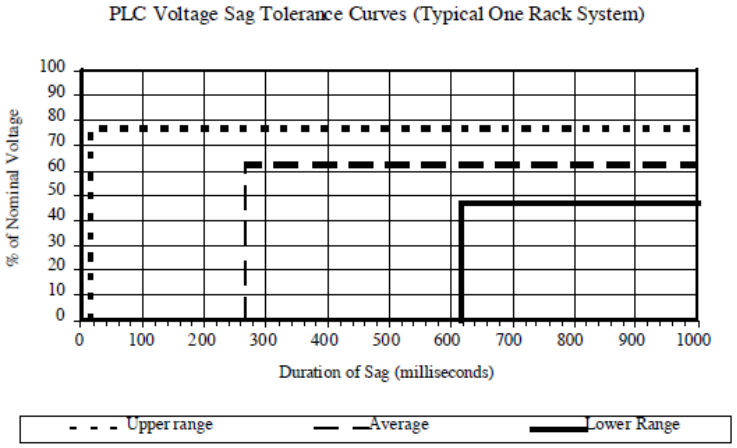
Voltage sag tolerance curves



From IEEE-1346-1998

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Protecting components

- Protection from physical damage during disturbances
  - Fusing to prevent damage during overloads or limit damage during faults in the control system itself
  - Surge suppression to prevent or limit damage during voltage transients
  - To the extent practical, locate control wiring away from power circuits
  - Consider inductive and capacitive coupling when routing control system wiring

Keeping control systems operating

- Specify voltage sag tolerance in design
  - SEMI F47 or other standards may be used
- Use DC – powered controls (with three-phase power supplies where applicable)
  - DC power-supplies provide inherent ride-through capability due to their capacitors used to filter the DC output power
- Match voltage specifications to supply
  - 240V equipment will usually run on 208V, but with less voltage sag ride-through

Keeping control systems operating

- Serve power supplies with a nominal voltage near the peak of their range
  - Increases energy stored in power supply's DC bus capacitors
- Power single-phase controls from line-to-line voltage
  - A single-phase interruption will allow a control power transformer to maintain 58% of nominal output voltage during loss of one phase.
- Power AC controls with UPSs
  - UPS can provide ride-through for voltage sags and short interruptions.

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Keeping control systems operating

- Don't overload power supplies
  - Remember homework 2's capacitor discharge problem?
  - Increased load on a power supply reduces its ride-through time – capacitor discharges more quickly
  - A lightly-loaded power supply operated at peak rated voltage will have significantly more ride-through than a heavily loaded power supply operating on a lower supply voltage

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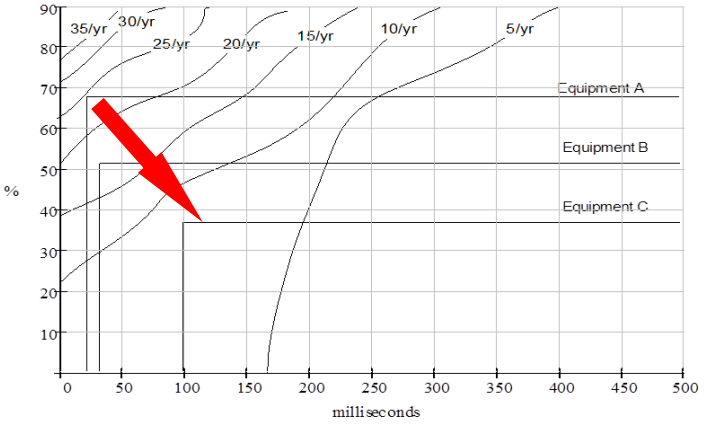
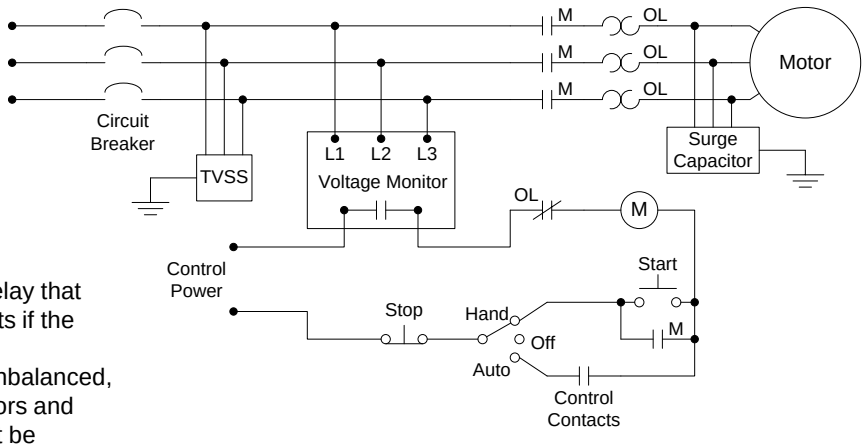
Objective is to push the corner of the compatibility curve down and to the right



Making the control system "PQ aware"

- Relays are available that can provide input to the control system when different PQ disturbances occur.
- In a simple, hard-wired control system these relays may be used to simply shut the entire system down.

Making the control system "PQ aware"



The Voltage Monitor is a relay that will open and close contacts if the supply voltage becomes unacceptable (high, low, unbalanced, etc.) This can protect motors and other equipment that might be damaged by these conditions.

Making the control system "PQ aware"

- It may not be desirable to simply de-energize the controls during certain power quality disturbances.
  - Motors may ride through voltage sags
  - Variable speed drives can be programmed with "flying restart" to detect motor speed and resume their programmed operation following a trip
  - Processes with thermal inertia are not likely to cool significantly during brief events

Making the control system "PQ aware"

- Conversely, if the controls stay "alive" they may direct the process to continue operating when the supply voltage is not compatible with the process equipment
  - Lost phase
  - Significant under or overvoltage
  - Phase reversal (very rare)

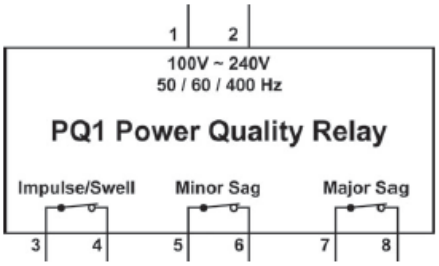
Making the control system "PQ aware"

- Some relay options – Voltage monitors
- Use adjustable thresholds
- Match thresholds to equipment tolerance
- Use output contacts as input to control system
- Design control system to respond in a desired way

Picture from ab.com

Making the controls "PQ aware"

- Power Quality relay
  - Opens different contacts based on event type
  - Thresholds are selectable



Pictures from powerstandardslab.com

Conclusions:

- Identifying control system vulnerabilities or "weak links," and making relatively minor changes to the control system will push the compatibility profile down and to the right, making the system less vulnerable to PQ disturbances.
- Keeping the controls "in control", adding power quality information to the control system, and designing the control system to respond to that power quality information can minimize the impact of power quality disturbances on processes.

References:

Some of the strategies described in this lecture were based on EPRI materials available at the following URL:

https://www.sceg.com/docs/librariesprovider5/pdfs/embeddedsolutionsapproachesthroughequipmentdesignstrategy.pdf

Next time…

- Begin wiring and grounding
- Please read PSQ chapter 10
  - Homework 7 available