# Power Quality Considerations in Distribution Engineering

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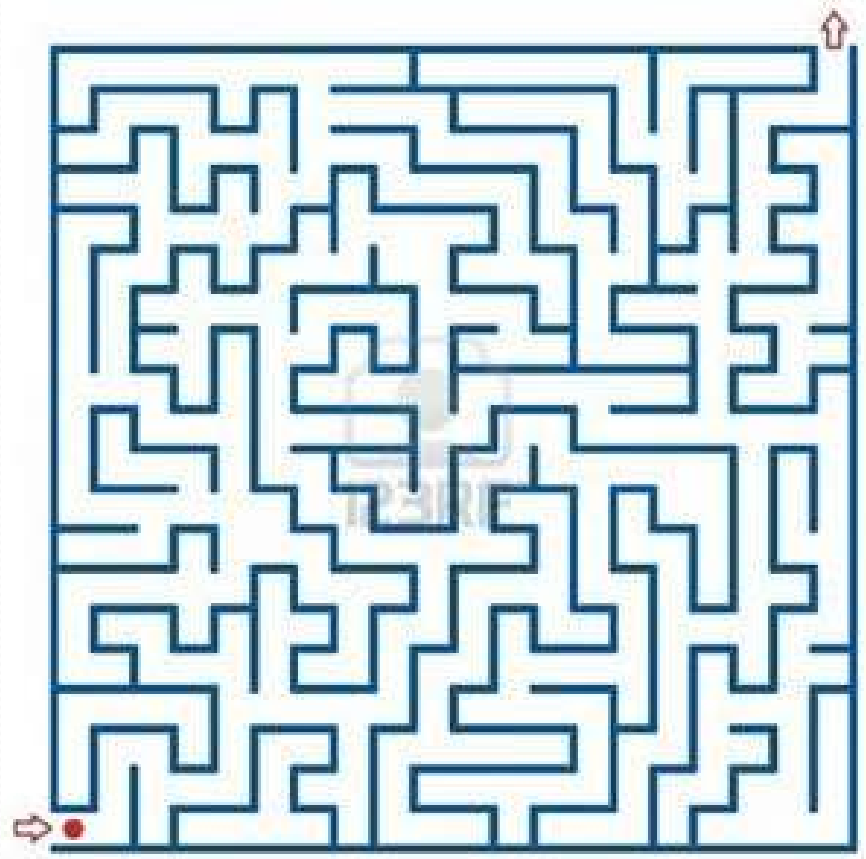
# Power Quality Maze



Solutions

Standards

# Power Quality Standards

- RUS Bulletin 61-2 & Other
- IEEE Standards (519 & C84.1)
- CRN Publications
- Other Standards

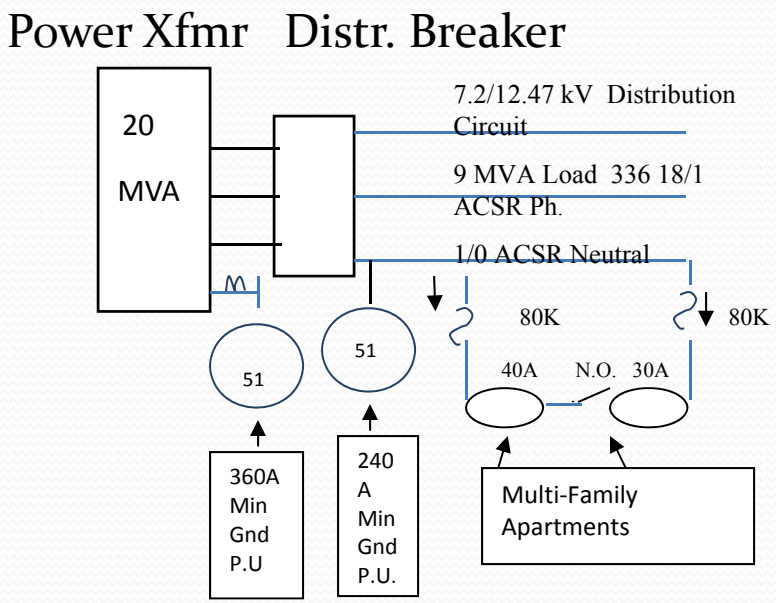
# RUS Bulletin 61-2

- 40 Ω Ground Rule
- Later USDA Bulletins allowed 30 Ω for Substation Transformers Over 5 MVA

**ANSI C57 Transformer Categories**

| Category | Single Phase (kVA) | Three Phase (kVA) | Permitted Minimum Ground Impedance |
|---|---|---|---|
| I | 5 to 500 | 15 to 500 | 40Ω |
| II | 501 to 1667 | 501 to 5000 | 40Ω |
| III | 1668 to 10,000 | 5001 to 30,000 | 30Ω |
| IV | Above 10,000 | Above 30,000 | 30Ω |

# Typical Single Phase Distr. Loading



# ANSI Standard for Volt Imbalance

- %Volt Imbalance =100x(Max –Ave)/Average
- Unloaded Service
- Example:Ph Voltages ;485;476;&477
- 485-479/479  100=1.25 %

# Measures to Improve Power Quality

| Distribution Design | Distribution Operations | Service Continuity | Power Quality |
|---|---|---|---|
| Larger Feeder Conductor | | | Decreased voltage drop |
| | Moving single phase to loads to balance feeder loading | Improved due to lower neutral currents | Improved service voltage balance |
| Larger Feeder Neutrals | | | Decreased voltage drop |
| Consider use of single phase reclosers on three phase feeders | | | Improved reliability on feeder. Decreased reliability for one phase of distribution feeder |
| Use of single phase regulators on distribution circuit | | | Improved voltage balance to three phase customers |
| Raising minimum ground trip level on feeder | | Increased due to lower incidence of ground trips | Possible increase in voltage imbalance |
| Install shunt capacitors on feeder & 3 phase taps | | Could decrease due to blown fuses | Increased due to lower $I^2R$ line losses |

# Increasing Neutral Pickup Settings

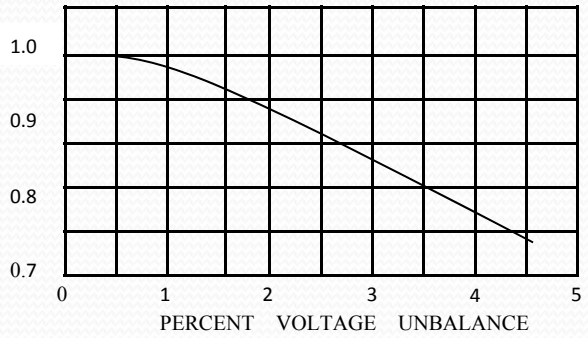
- Reduces Possibility of Tripping for Imbalance
- Raises Possibility of Excessive Voltage Imbalance
- Derate 3 Phase Motors

# Increasing Volt Imbalance

Electric supply systems should be designed and operated to limit the maximum voltage unbalance to 3 percent when measured at the electric-utility revenue meter under no load conditions.

- Consequences-Motors Overheat –Derated Below 88%

# Three Phase Motor Derating



# Utilization Voltages(120-600V)

- Nominal -120V
- 120-600V Service-114-126
- Systems >600V-117-126
- Service Utilization Voltages(Range A)-110-125

# Service and Utilization Voltages(Systems>600 Volts )

- Nominal -120V
- 120-600V Systems -110-127
- Systems >600V-114-127
- Service Utilization Voltages(Range A)-106-126

# Service and Utilization Voltages(Delivery Volt >600 Volts )

- Nominal -120V
- Service Utilization Voltages 120-600V Systems-108-126
- Service Utilization Voltages for Systems >600V-104-127

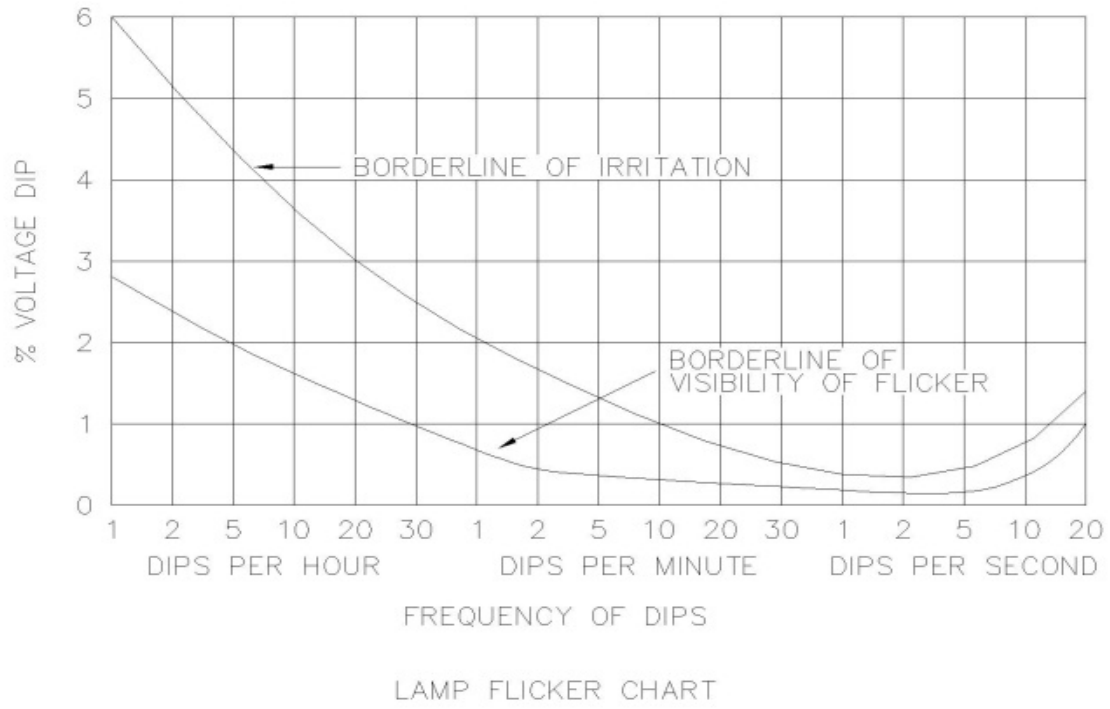
# Voltage Distortion ANSI 519-1992

| Bus Voltage at PCC | Individual Voltage Distortion (%) | Total Voltage Distortion THD (%) |
|---|---|---|
| 69 kV and below | 3.0 | 5.0 |
| 69001 V through 161 kV | 1.5 | 2.5 |
| 161001 kV and above | 1.0 | 1.5 |

# Current Distortion Limits for General Distribution Systems (120 V through 16900 V

| Maximum Harmonic Current Distortion in Percent of $I_L$ | | | | | | |
|---|---|---|---|---|---|---|
| **Individual Harmonic Order (Odd Harmonics)** | | | | | | |
| $I_{SC}/I_L$ | <11 | 11≤h<17 | 17≤h<23 | 23≤h<35 | 35≤h | TDD |
| <20 | 4.0 | 2.0 | 1.5 | 0.6 | 0.3 | 5.0 |
| 20<50 | 7.0 | 3.5 | 2.5 | 1.0 | 0.5 | 8.0 |
| 50<100 | 10.0 | 4.5 | 4.0 | 1.5 | 0.7 | 12.0 |
| 100<1000 | 12.0 | 5.5 | 5.0 | 2.0 | 1.0 | 15.0 |
| >1000 | 15.0 | 7.0 | 6.0 | 2.5 | 1.4 | 20.0 |

# Design Voltage Flicker Chart



# ANSI 1453-2011 Measuring Flicker

- Plt: is calculated as the cubic average of 12 consecutive Pst values obtained for a 2 hour period.

$$Plt = \sqrt[3]{1/12} \sum_{1}^{12} Pst$$

- Recommended planning levels for medium voltage distribution systems are 0.9 for Pst and 0.7 for Plt.

# Ways to Mitigate Flicker

- Soft Start
  - Wye-Delta starters
  - Autotransformers
  - Static Electronic Soft Start Systems
- Steady State and Starting
  - Liquid Rheostats
  - Static VAR Compensators
  - DC Motor Systems

# Shunt Capacitors &Flicker

## Fig (a)$E_L$=91%$E_S$ . Fig(b)$E_L$=111%$E_S$ With Switch Closed

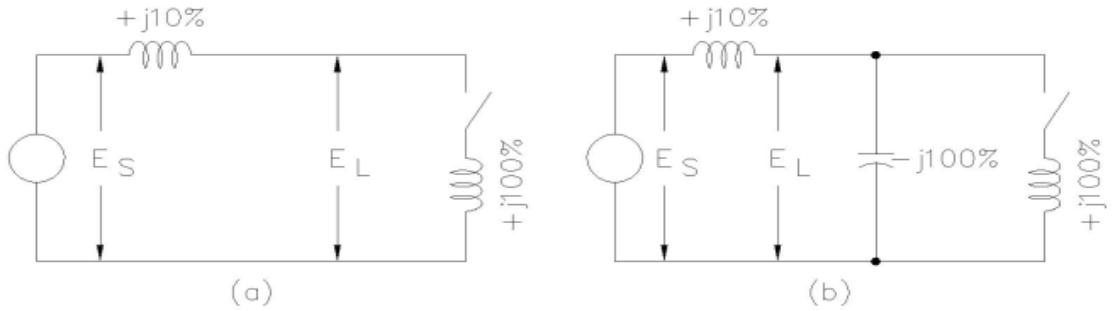



FIGURE 2

# Conclusions

**Action**

- Improving One Power Quality Parameter
- Raising Minimum Trip Values

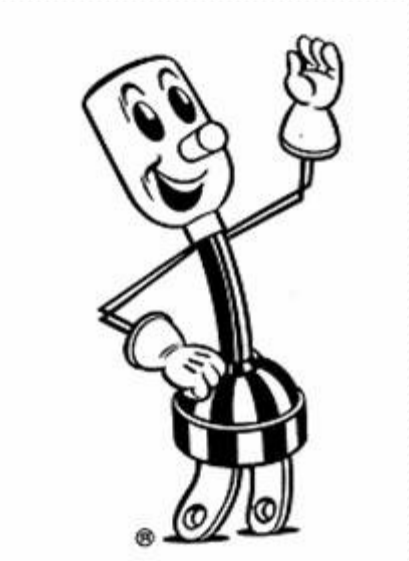
**Effect**

- Can Create a Negative Impact on Another
- Create Greater Voltage Imbalance

# Conclusions

- Power Quality Can Be Made Easier
  When Armed  With The Right Standards

# Questions



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