EE 741 Spring 2017

Electric Power Distribution Systems – An Overview

Basic Power System Layout



There are over 100 substations in the Las Vegas Valley – pic of closest substation



Substation Design



Factors affecting substation expansion



Factors affecting substation siting



Substation Site Selection Procedure



Load Characteristics

- Customer load
- Diversity
- Metering
- Load control







Power Transformers

- Substation transformers
- Distribution transformers







Design of primary and secondary systems





Voltage drop and power loss calculations

$VD \approx I(R\cos\theta + X\sin\theta)$ $P_{loss} \approx I^2 R$



Voltage regulation and capacitor application

- LTC @ substation transformer
- Voltage Regulators
- Fixed and switched shunt capacitors









Distribution System Protection

- Overvoltage Protection
- Overcurrent Protection





Distribution System Reliability

- Sustained interruption indices (e.g., SAIDI, CAIDI, ...)
- Other indices (momentary)
- Load and energy based indices



Electric Power Quality

- Continuity of service
- Variation in voltage magnitude
- Transient voltages and currents
- Harmonic content in the waveforms
- Power Quality Indices





Distributed Generation



https://www.dg.history.vt.edu/ch1/introduction.html

Distribution Automation

- Generation and transmission systems have been automated for some time through SCADA.
- Distribution Automation is relatively new now part of the utility Energy Management System (EMS)



Distribution Automation

- Distribution automation has a broad meaning and additional applications are added on a regular basis:
 - It is an integrated concept of the automation of distribution substations, feeders and loads.
 - It includes communication, control, monitoring, protection, load management, and remote metering of consumer loads.
 - It is fueled by increased reliability reporting requirements, need to operate the system closer to its design limits, increased efficiency requirements, and tendency to monitor customer load behavior.
- The benefits include improved quality and continuity of supply, voltage level stability, reduced system losses, reduced investment, reduced workforce.

Automation and Control Functions

- Load management
 - direct load switching,
 - peak load pricing,
 - load shedding,
 - cold load pick-up (loss of diversity and inrush)
- Operational management
 - feeder load re-configuration,
 - transformer load management,
 - voltage regulator and control of switched capacitors,
 - fault detection-location-isolation
- Remote meter reading
 - automatic customer meter reading,
 - dispersed storage and generation

Communication

- Many communication methods are available:
 - Dial-up and dedicated leased telephone lines
 - Power Line Carrier
 - Radio control (UHF point-to-point and multi-address system, VHF radio (one-way), packet switching network, cellular radio)
 - Fiber optics
 - Microwave
 - Satellite communications



https://electrical-engineering-portal.com/communications-power-system-protection