ECET 211 Electric Machines & Controls

Lecture 3-1 (Part 1 of 2)

Motors, Transformers and Distribution Systems

Text Book: Electric Motors and Control Systems, by Frank D. Petruzella, published by McGraw Hill, 2015.

Paul I-Hai Lin, Professor of Electrical and Computer
P.E. States of Indiana & California
Dept. of Computer, Electrical and Information Technology
Purdue University Fort Wayne Campus

Lecture 3 Motor, Transformers and Distribution Systems

- Chapter 3. Motor Transformers and Distribution Systems
  - **Part 1. Power Distribution**
  - **Part 2. Transformer Principles**
  - **Part 3. Transformer Connections and Systems**

Lecture 3 Motor Transformers and Distribution Systems

- Part 1. Power Distribution

Transformers

- Electrical apparatus that transfer electrical energy from one electrical circuit to another by magnetic coupling
- Transfer electricity from one electric circuit to another by means of electromagnetic mutual induction
- Roles that transformers play in motor power distribution and control systems
- The purpose: converts AC power at voltage level to AC power of the same frequency at another voltage level

Distribution System

- Refers to the manner in which electrical energy is transmitted from the generators to its many point of use

Figure 3-1 Transformation stages of a power distribution system

- High voltages used in transmission lines => reduce the amount of current flow
- Power on low voltage side = (V_{Low}* I_{Low})= Power on high voltage side = (V_{high} * I_{high})
- Reduce current I => reduce the conductor size => cost saving
- Minimize the voltage drops (I* R_{wire}) and power lost (I^2R_{wire})

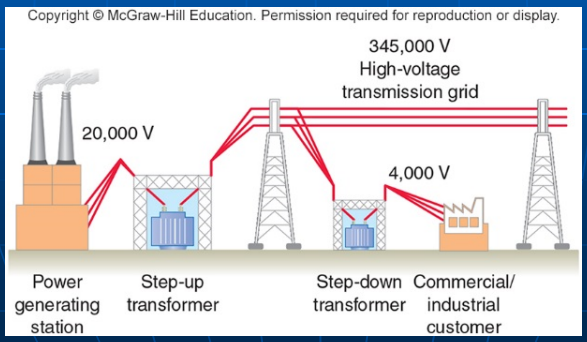
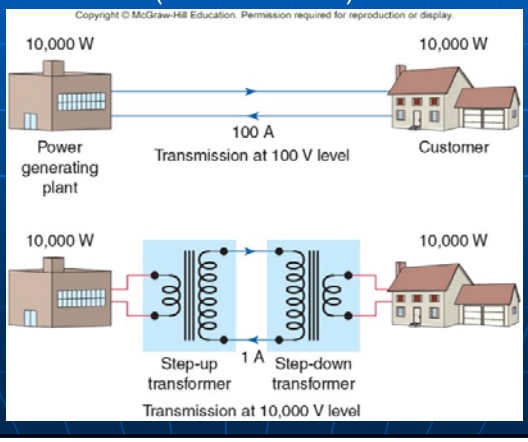


Figure 3-2 High voltage reduces the required amount of transmission current required

- 100 A vs. 1 A for efficient electrical energy distribution and transmission
  - P = V * I = 100 V * 100A = 10,000 W without transformers
  - P = V* I = 10,000 V * 1A = 10,000 W with transformer
- Power loss of transformer (10% to 2 or 1%)

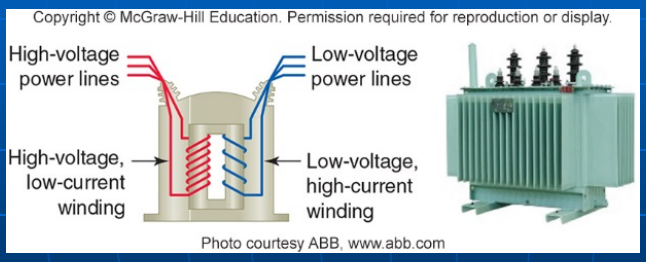


5

Lecture 3 Motor Transformers and Distribution Systems

- Chapter 3. Motor Transformers and Distribution Systems
- Part 1. Power Distribution

Figure 3-3 Power Grid Transformers



Lecture 3 Motor Transformers and Distribution Systems

- A power substation consists of equipment installed for switching, changing or regulating line voltage

Figure 3-4 Factory assembled unit substation

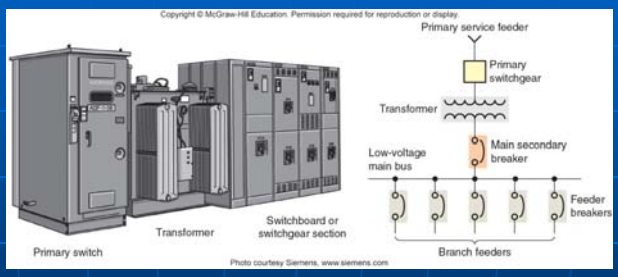


Figure 3-5 Single-line diagram for a typical unit substation: High-voltage primary switchgear, Transformer section, Low-voltage distribution section

Distribution Systems

- Used to distribute power throughout large commercial and industrial facilities.
- Power must be distributed through various switchgears, transformers, and panelboards.

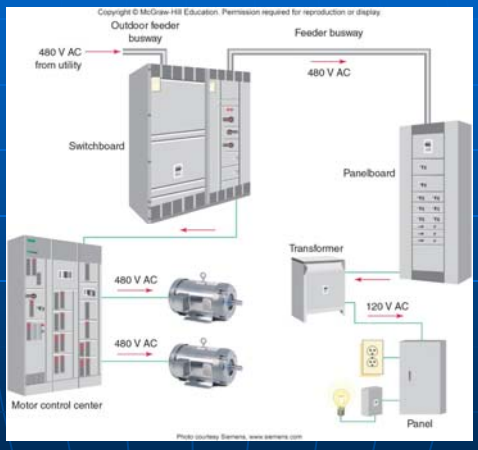


Figure 3-6 Typical commercial/industrial distribution system

Distribution Systems

- Sections of a typical electrical distribution system
  - Service entrance
  - Feeders
  - Branch circuits

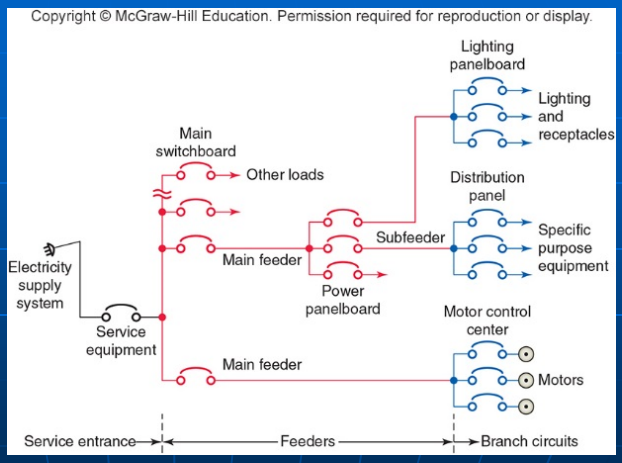


Figure 3-7 Single-line diagram for a typical electrical distribution system

Conductor Ampacity and Common Types of Raceways

- Conductor Ampacity – the maximum amount of current the conductor can safely carry without becoming over heat,
- NEC Conductor size, insulation, and operating condition
  - NEC Article 310: Conductors for General Wiring, http://www.houwire.com/products/technical/article310_16.html
- Types of Raceways
  - Conduit
  - Cable Trays
  - Low-impedance Busways (bus duct)
  - Plug-in busways

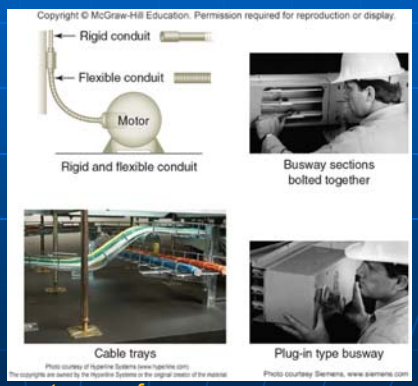


Figure 3-8 Common types of raceways

Power Losses

- Power Losses
  - Transmission loss
  - Distribution loss
- Common example of losses in the power gird
  - Line losses (I^2 *R)
  - Transformer losses (no-load losses)
  - Poor power factor losses
    - P = V*I* Cosθ – single phase load
    - P = √3* V*I* Cosθ = 1.732* V*I* Cosθ – three phase load
  - Power factor correction apparatus/device - capacitor

Switchboards and Panel boards

- Typical combination service entrance and switchboard installed in a commercial building:
  - Service entrance
  - Switchboard
  - Main switch

Figure 3-9 Combination service entrance switchboard

Switchboards and Panelboards

- A Panelboard - contains a group of circuit breaker of fuse protective devices for lighting, convenience receptacles and power distribution branch circuits

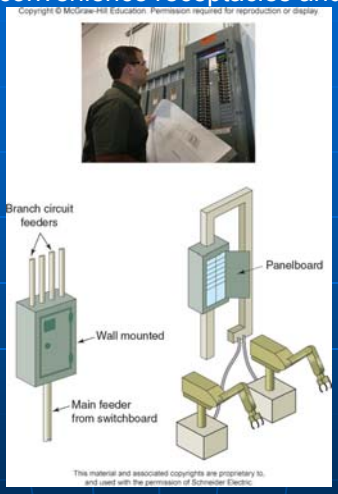


Figure 3-10 Typical panelboard installation

Switchboards and Panelboards

- Typical internal wiring for a 277/480 V, three-phase, four-wire panel equipped with circuit breaker.
- V_L (Line-to-Line voltage) = 480V
- V_{LN} (Line to neutral voltage) = 480/√3 = 480/1.732 = 277 V => for single phase lighting load, motor load

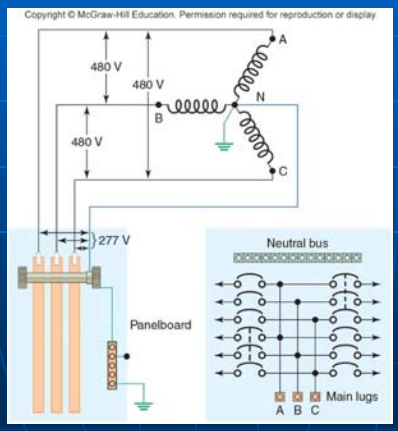


Figure 3-11 Wiring for a 277/480 V, three-phase, four-wire panelboard

Switchboards and Panelboards

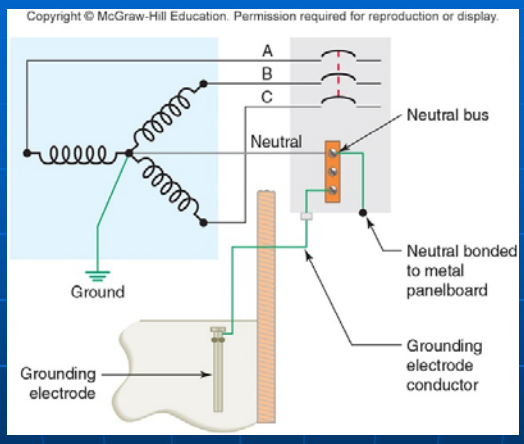


Figure 3-12 Panelboard grounding and bonding

Switchboards and Panelboards

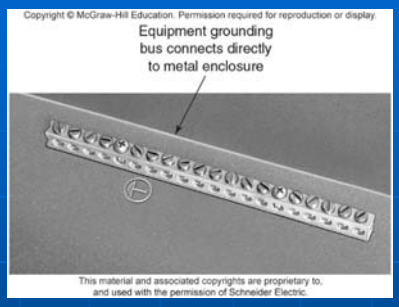


Figure 3-13 Equipment grounding bus

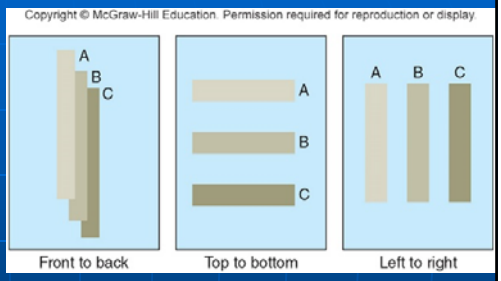


Figure 3-14 Phase arrangement on three-phase buses: phase A, phase B, phase C

Switchboards and Panelboards

- NEMA numbering – Even numbers on right side, Odd number on left-side

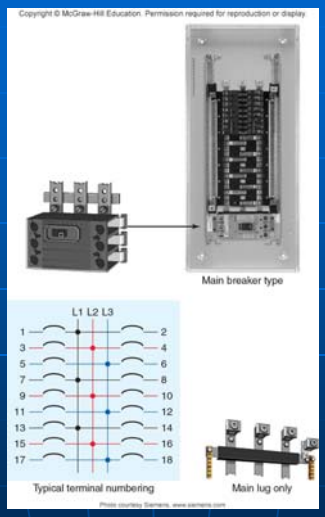


Figure 3-15 Pannel board configuration

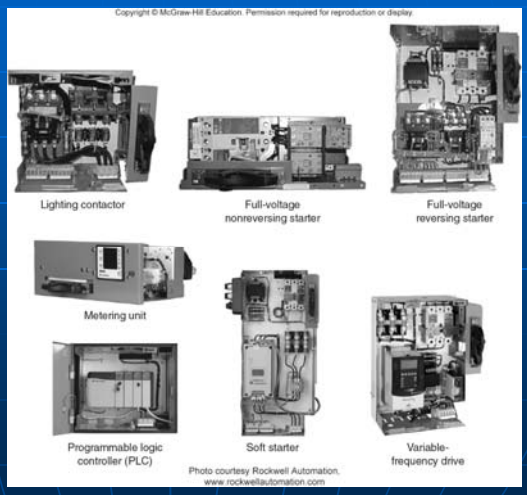
Motor Control Centers (MCCs)

- For installing the Incoming power, Control circuitry, Overload and over current protection equipment

Figure 3-16 Typical motor control centers

Figure 3-17 Major Components of Motor Control Centers

- Feeder circuit breakers, Feeder fusible disconnects, Transformers, Metering equipment
- Contactors, NEMA and IEC non-reversing and reversing full-voltage starters, soft starters, AC variable frequency drives', PLCs, Solid-state motor controllers



19

Summary & Conclusion

Questions?

Contact Prof. Lin through:

- Email: lin@ipfw.edu