

# First Course on Power Systems

## Module 7: Distribution System, Loads and Power Quality

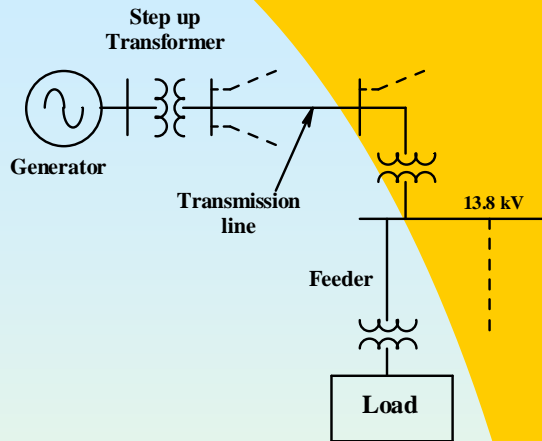
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**Reference Textbook:**  
**First Course on Power Systems by Ned Mohan,**  
**[www.mnpere.com](http://www.mnpere.com)**

# Module 7: Distribution System, Loads and Power Quality

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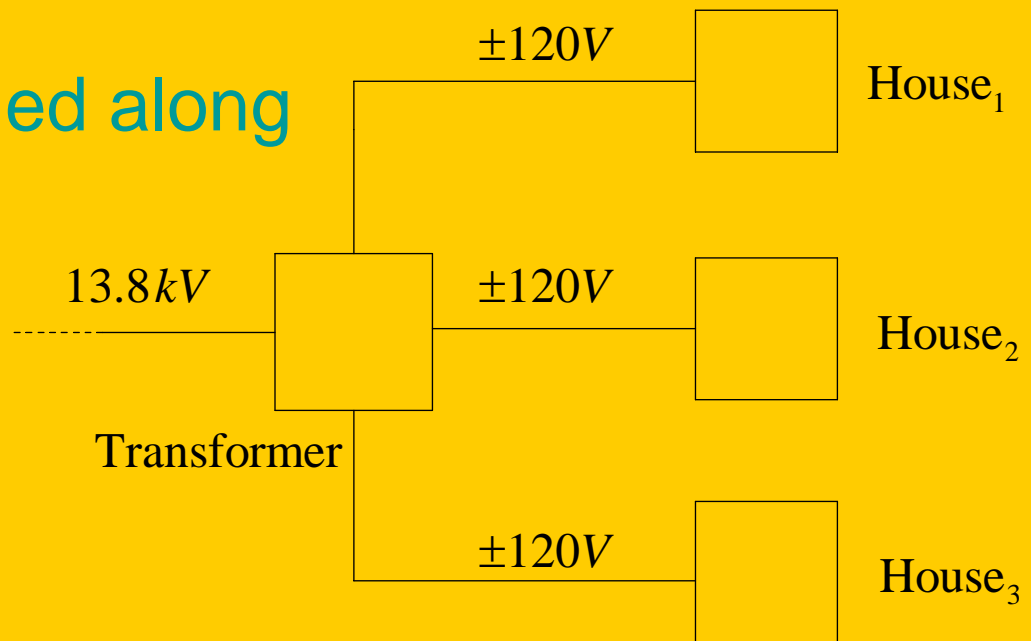
# Distribution System



- 9% of Electric Loss
- Sub-transmission at 230 kV or below
- 35 kV and down to 12 kV
  - ◆ Secondary Voltages at 600 V, 480/277 V (3-phase, 4-wire), 208/120 V

# Residential Distribution System

- 1-Phase Distribution Lines at 13.8 kV
- Stepped down locally to  $\pm 120V$
- Neutral Grounded at the House Entrance
- Ground Wire is carried along
- GFI



# • Power System Load

## Daily Load Curve

## Load-Duration Curve

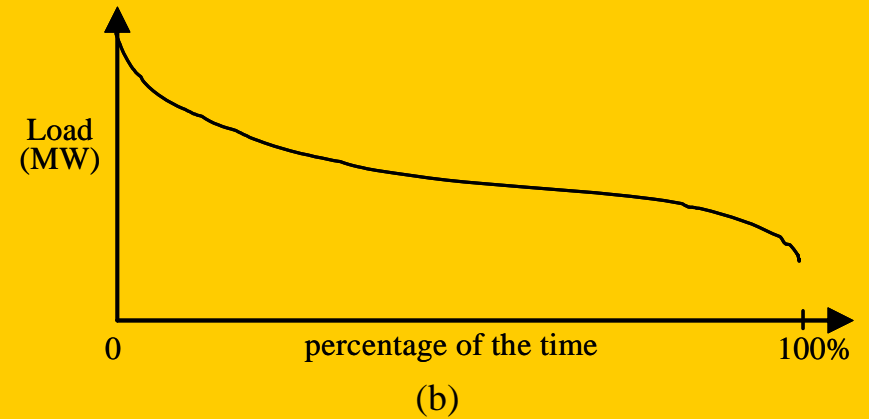
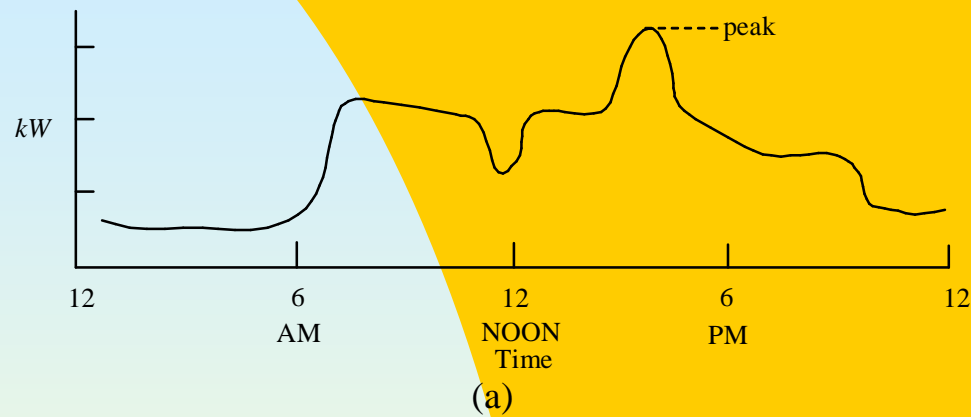
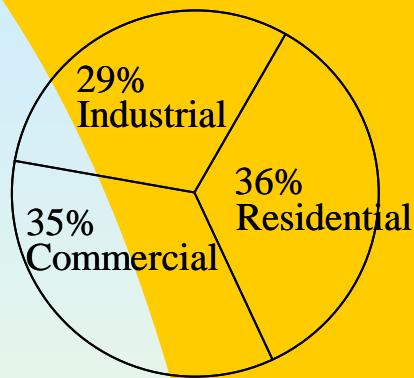


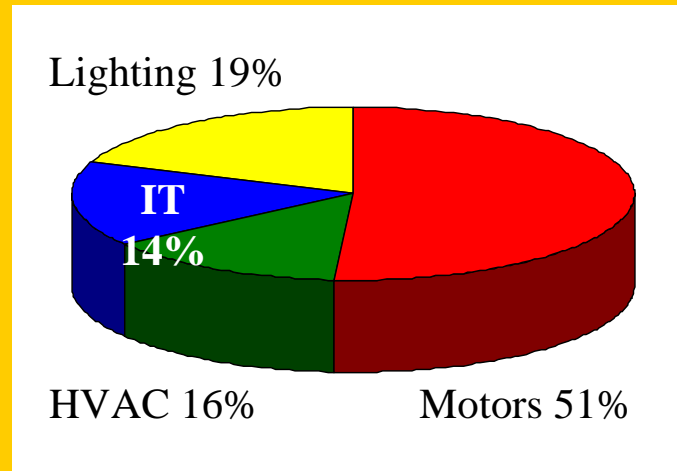
Fig. 8-2 System load.

- Load Factor
- Storage
- Load Forecasting
- Renewable Energy

# Utility Load Distribution



(a)



(b)

Fig. 8-3 Utility loads.

— PHEV

# Power Factor and Voltage Sensitivity of Power System Loads

Table 8-1 Power Factor and Voltage Sensitivity of Power Systems Load

Type of Load	Power Factor	$a = \partial P / \partial V$	$b = \partial Q / \partial V$
Electric Heating	1.0	2.0	0
Incandescent Lighting	1.0	1.5	0
Fluorescent Lighting	0.9	1.0	1.0
Motor Loads	0.8 – 0.9	0.05 – 0.5	1.0 – 3.0
Modern Power-Electronics based Loads	1.0	0	0

# Voltage-Link System used in Power Electronics Based Loads

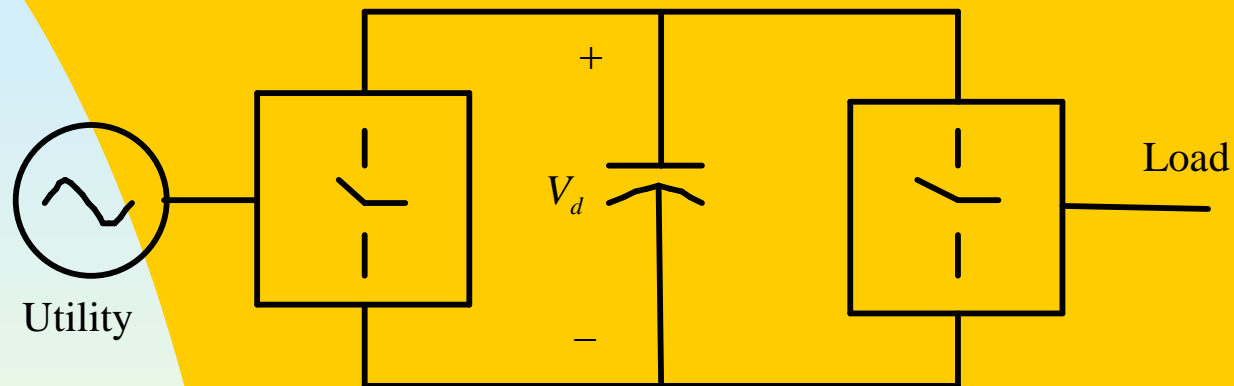


Fig. 8-4 Voltage-link-system for modern and future power-electronics based loads.

- Higher System Efficiency
  - Heat Pumps and CFLs



# Induction Motor Per-Phase Diagram

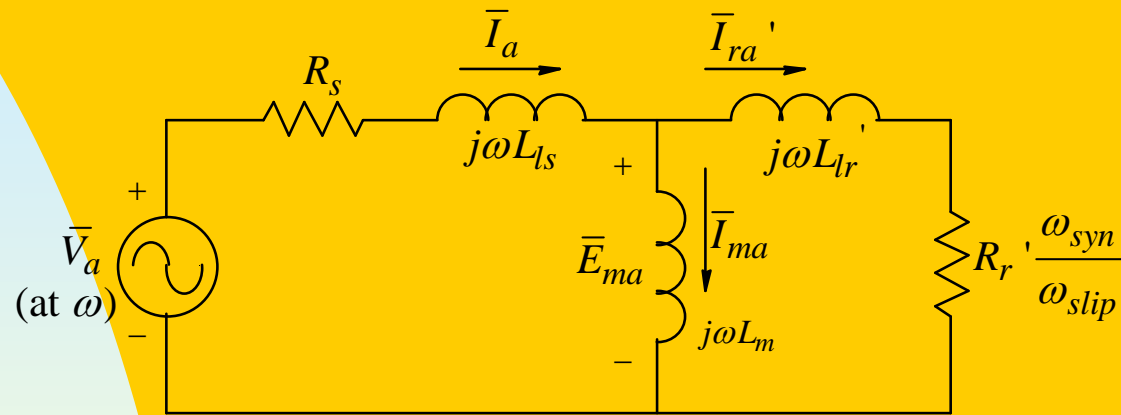


Fig. 8-5 Per-phase, steady state equivalent circuit of a three-phase induction motor.

- Conventional Speed Control by Reducing Voltage
  - High slip speed result in large rotor losses

# Variable-Speed Drives

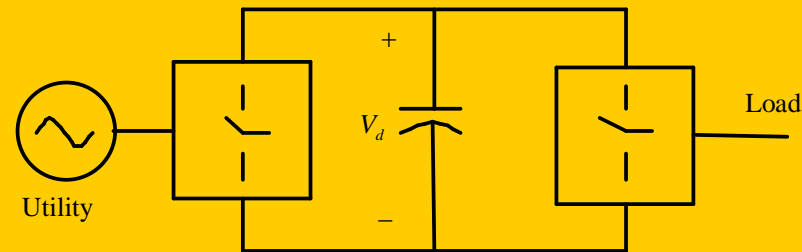
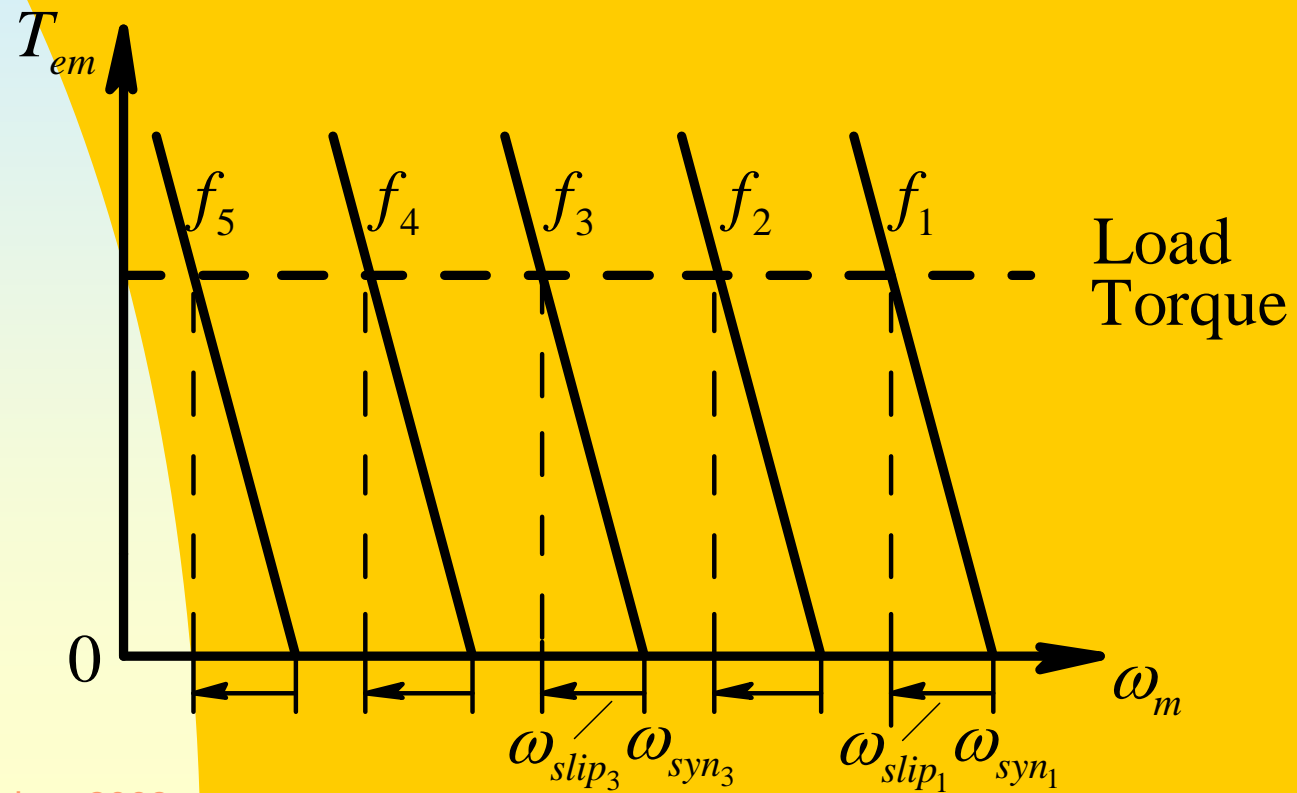


Fig. 8-4 Voltage-link-system for modern and future power-electronics based loads.



# Switch-Mode DC Power Supplies

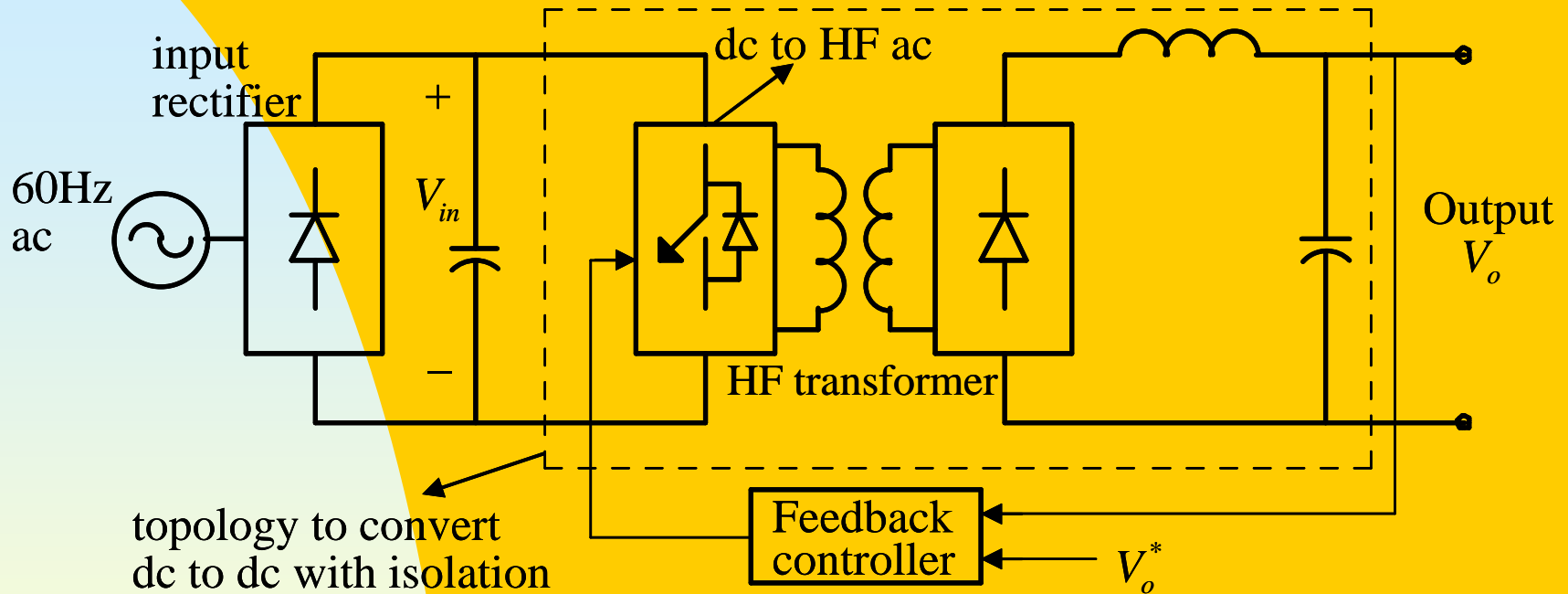


Fig. 8-7 Switch-mode dc power supply.

- Efficiencies 90% and Higher