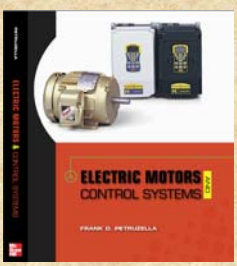

Chapter 3

Motor Transformers and Distribution Systems

PART 1 Power Distribution Systems

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TRANSMISSION SYSTEMS

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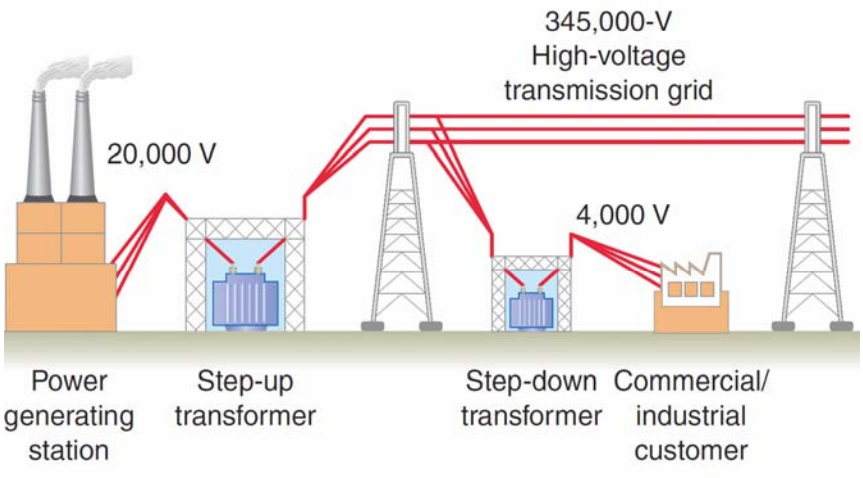
Transmitting large amounts of electric energy over long distances is accomplished most efficiently by using high-voltages.



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Without transformers the widespread distribution of electric power would be impractical. The main purpose of a transformer is to convert AC power at one voltage level to AC power of the same frequency at another voltage level.

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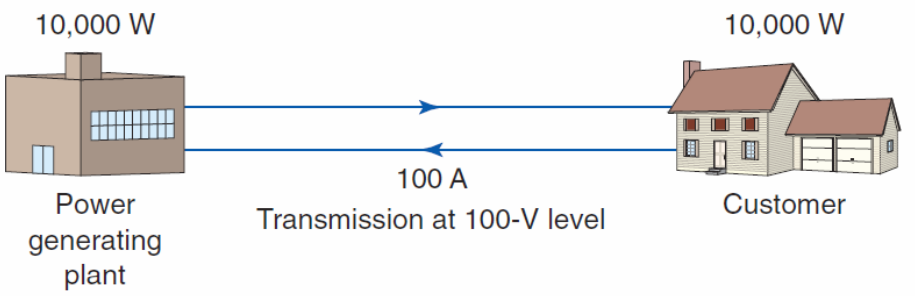
High voltages are used in transmission lines to reduce the required amount of current flow.



Power = Voltage x Current
= 100 V x 100 A
= 10,000 Watts

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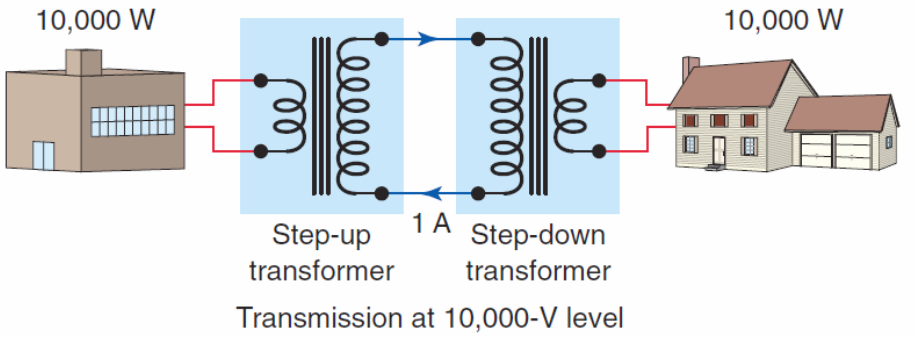
Transmission @ 10,000 volts
Current reduced from 100 A to 1 A



If the voltage is raised, the current can be reduced to a small value, while still transmitting the same amount of power

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Because of the reduction of current flow at high voltage, the *size and cost* of wiring are greatly reduced.

Reducing the current also *minimizes voltage drop* (*IR*) and amount of *power lost* (I^2R) in the lines.

For a given amount of power delivered, doubling the transmission voltage cuts the electrical loses by 75 percent.

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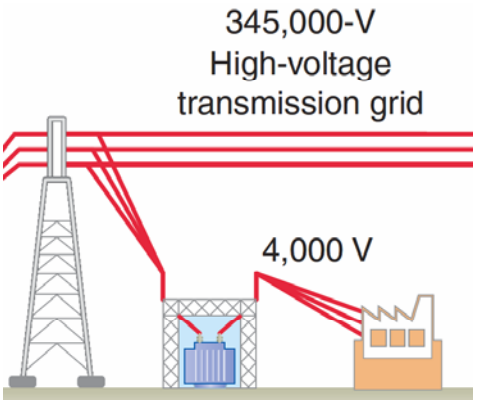
The higher the voltage, the more difficult and expensive it becomes to safely insulate between line wires, as well as from line wires to ground. For this reason, the voltages in a typical high-voltage grid system are reduced in stages as they approach the area of final use.



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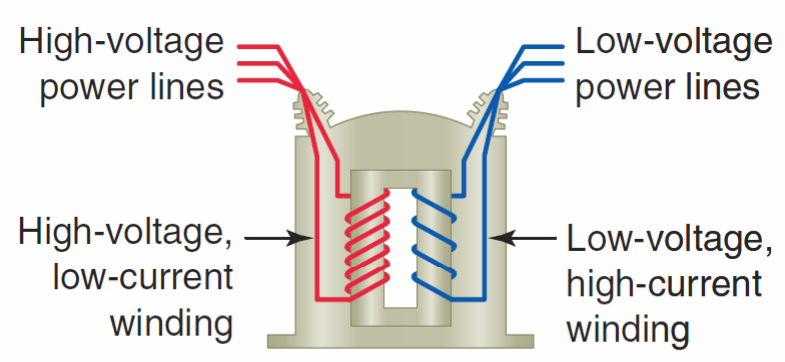
Transformers make possible conversion between high and low voltages and accordingly between low and high currents.



Compare to the high voltage side, the low voltage side of a transformer draws more current.

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UNIT SUBSTATIONS

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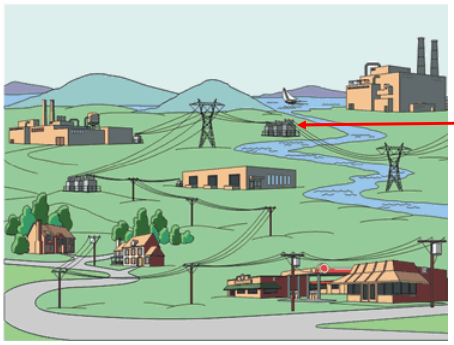
The place where the conversion from *transmission* to *distribution* occurs is in a *power substation*. It has transformers that step transmission voltage levels down to distribution voltage levels.



A power substation consists of equipment installed for switching, changing, or regulating line voltages.

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The power needs of some users are so great that they are fed through individual substations dedicated to them. These secondary *unit substations* form the heart of an industrial or commercial building's electrical system.

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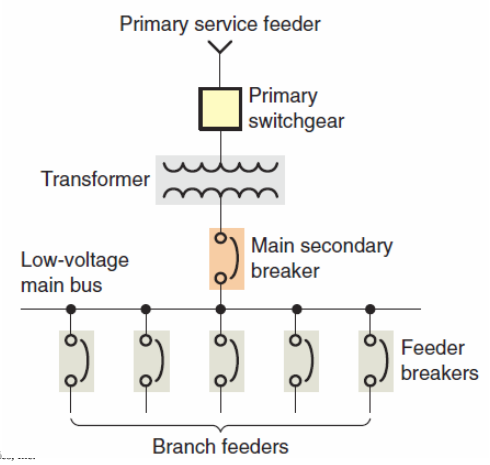
Unit substations receive the electric power from the utility and step it down to the utilization voltage level of 600 V or less for distribution throughout the building.



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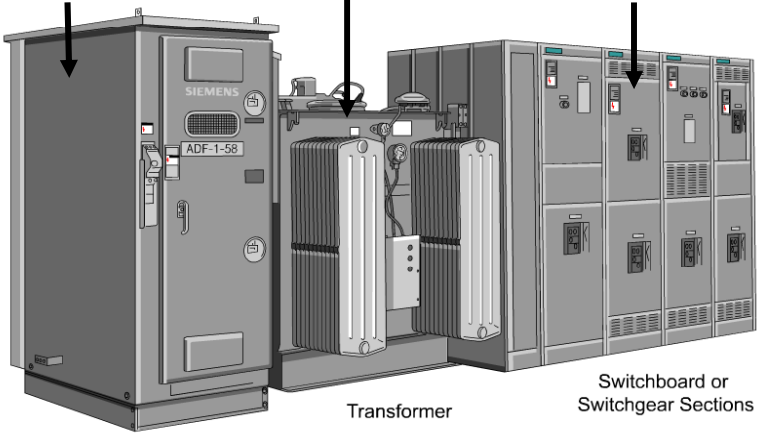
Incorporates the terminations for the primary feeder cables and primary switchgear.

Steps down the primary voltage to the low-voltage utilization level.

Provides the protection and control for the low-voltage feeder circuits.



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DISTRIBUTION SYSTEMS

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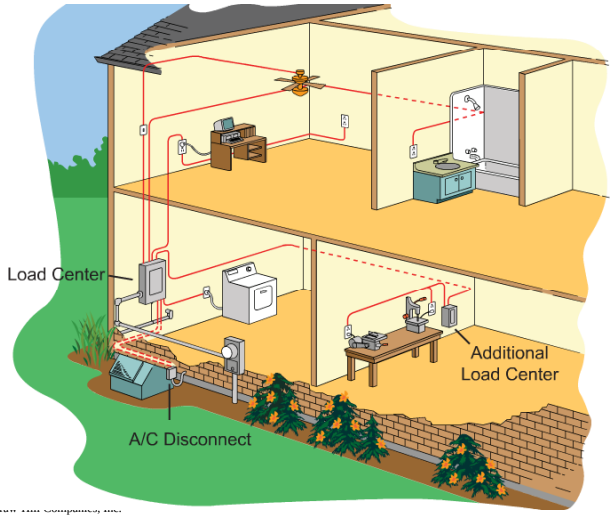
Distribution systems **are used to distribute power throughout residential, commercial, and industrial buildings.**



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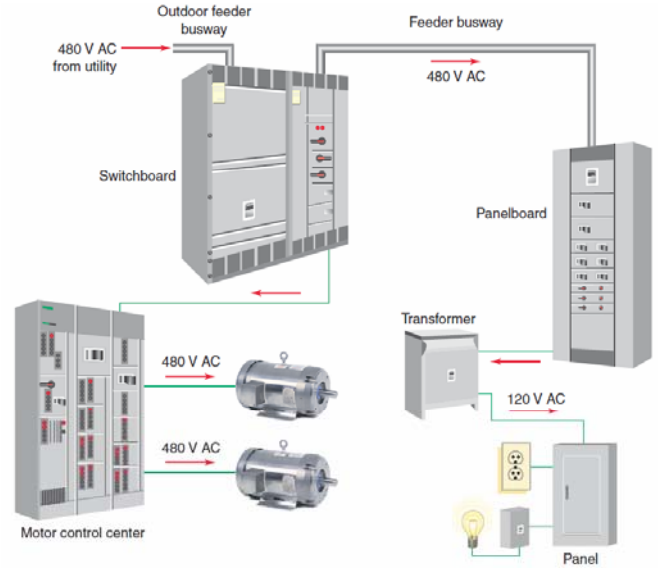
Distribution systems used to distribute power throughout large commercial and industrial facilities can be complex.



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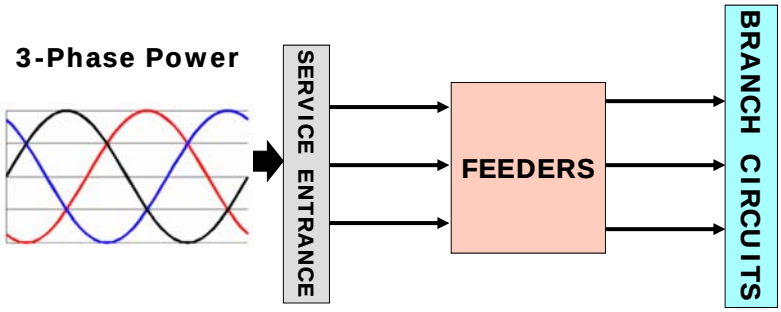
Typically the distribution system is divided into the:

- **Service Entrance Section**
- **Feeder Section**
- **Branch Circuits Section**



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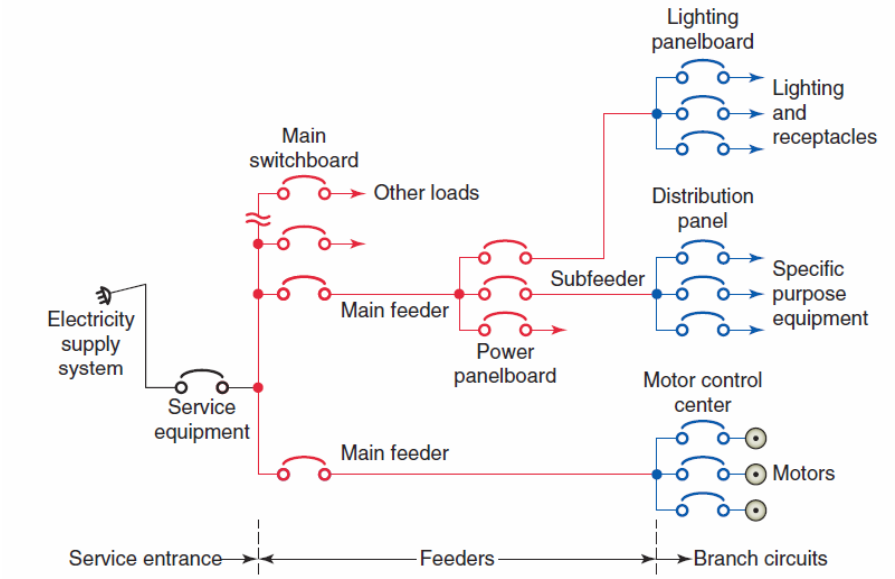
Distribution System - Line Diagram



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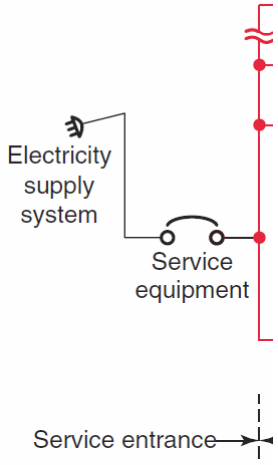
The *service entrance* section includes conductors for delivering energy from the electricity supply system to the premises being served.



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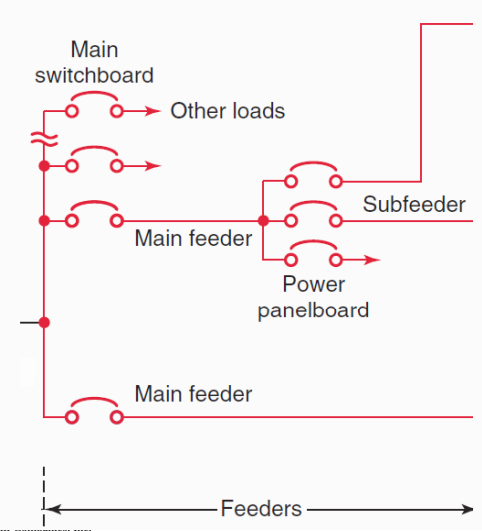
A *feeder* is a set of conductors that originate at a main distribution center and supply one or more secondary or branch circuit distribution centers.



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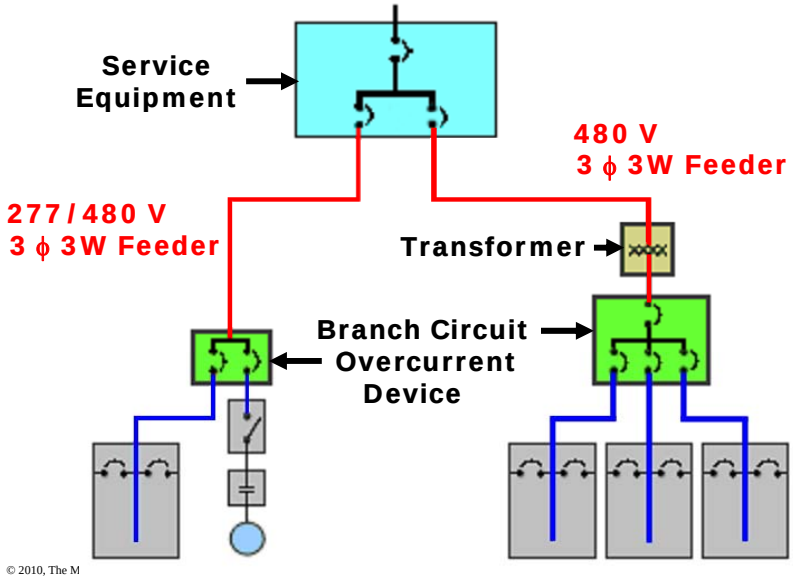
The feeder section includes conductors for delivering the energy from the service equipment location to the final branch- circuit overcurrent device.



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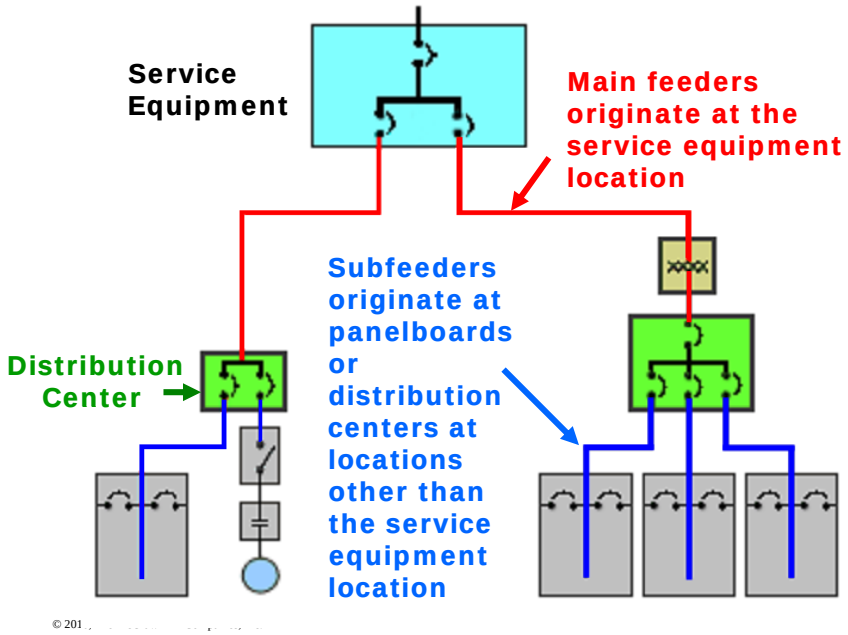
Main Feeders and Subfeeders



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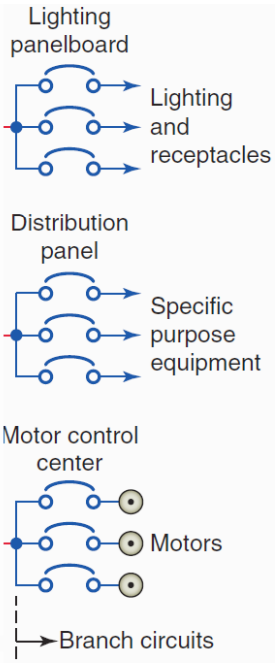

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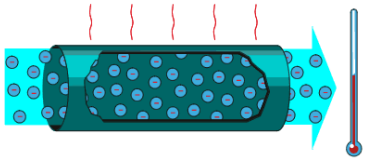
The *branch circuit* section includes conductors for delivering the energy from the point of the final overcurrent device to the utilization equipment.

Correct selection of conductors for feeders and branch circuits must take into account *ampacity*, *short circuit*, and *voltage drop* requirements.

The ampacity rating of conductors in a raceway depends on:

- ***the conductor material, gauge size, and temperature rating***
- ***number of current-carrying conductors in the raceway***
- ***the ambient temperature***



Current flow always generates heat

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The NEC (National Electrical Code) contains tables that list the ampacity for approved types of conductor size, insulation, and operating conditions.

Size	Temperature Rating Of Conductor		
AWG or kcmil	60°C (140°F)	75°C (167°F)	90°C (194°F)
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2
	COPPER		
18	—	—	14
16	—	—	18
14*	20	20	25
12*	25	25	30
10*	30	35	40
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	110
2	95	115	130
1	110	130	150

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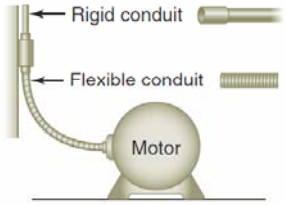
All conductors installed in a building must be properly protected, usually by installing them in *raceways*.



Rigid and flexible conduit


Busway sections bolted together


Cable trays


Plug-in type busway

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SWITCHBOARDS AND PANELBOARDS

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The Code defines a *switchboard* as a single panel or group of assembled panels with buses, overcurrent devices, and instruments.

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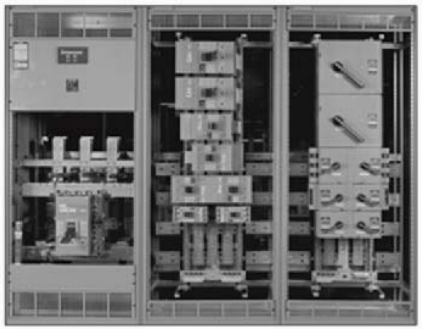
Typical combination *service entrance* and *switchboard*. The service entrance section has space and mounting provisions required by the local utility for metering purposes. The switchboard section controls the power and protects the distribution system through the use of switches, fuses, circuit breakers, and protective relays.



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A *panelboard* contains a group of circuit breaker or fuse protective devices for lighting, convenience receptacles, or power distribution branch circuits

They make up the part of the distribution system that provides the last centrally located protection for the final power run to the load and its control circuitry.

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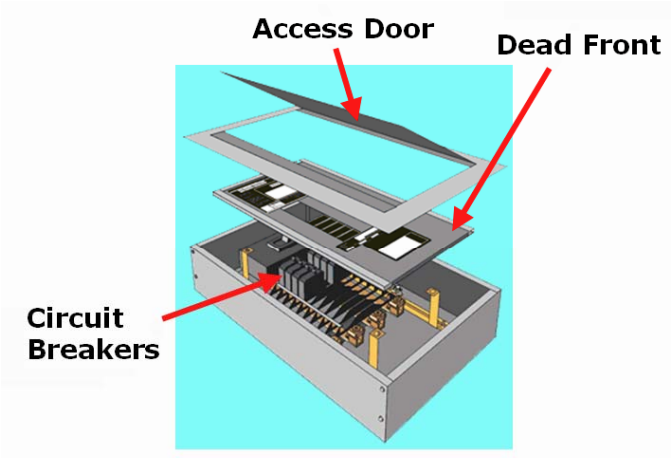
Panelboards are placed in a cabinet or cutout box, which is accessible only from the front and have dead-fronts. Dead front is defined in the Code as having no exposed live parts on the operating side of the equipment.



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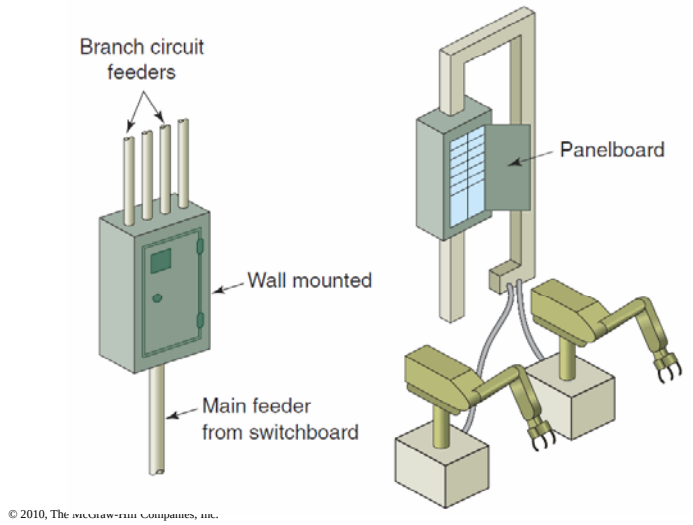
The panelboard is usually supplied from the switchboard and further divides the power distribution system into smaller parts.



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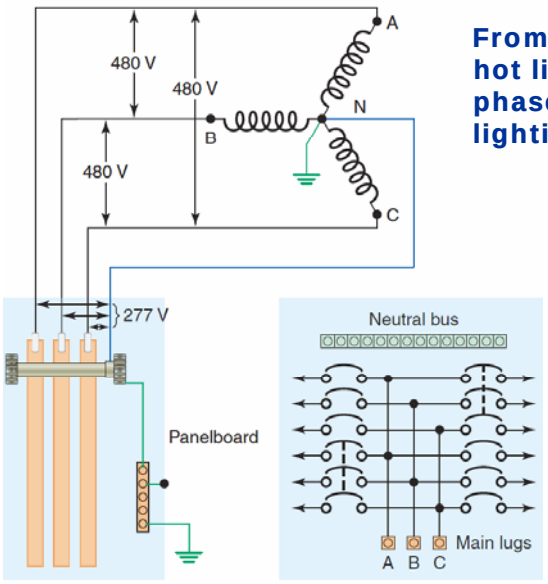
277/480-volt three-phase 4-wire panelboard



From neutral (N) to any hot line, 277 volts single-phase for fluorescent lighting can be obtained.

Across the three hot lines (A-B-C) 480 volts three-phase is present for supplying motors.

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The proper ***grounding*** and ***bonding*** of electrical distribution systems in general and panelboards in particular is very important.

Grounding is the connection to earth, while **bonding** is the connection of metal parts to provide a low impedance path for fault current to aid in clearing the overcurrent protection device and to remove dangerous current from metal that is likely to become energized.

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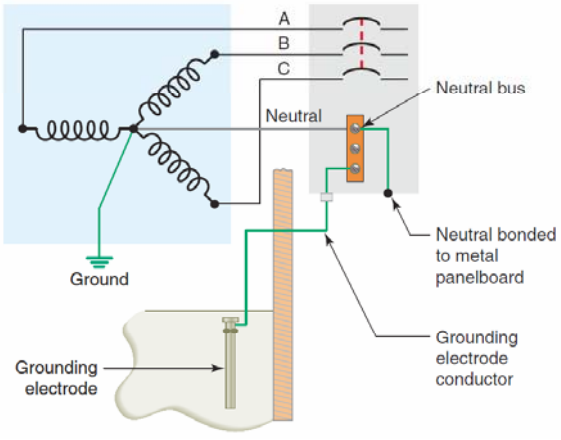
The ***main bonding jumper*** gives you ***system grounding***. If a transformer is immediately upstream of the panelboard, you must bond the neutral bus or neutral conductor to the panel enclosure and to a (bare) grounding-electrode conductor.



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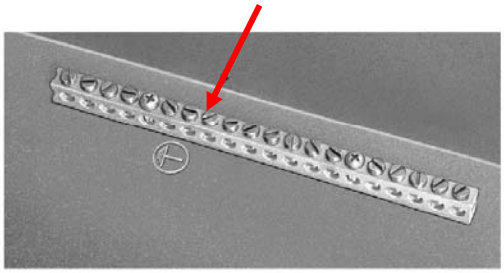
The Code requires the panelboard cabinets to be connected to an equipment grounding conductor. A separate equipment grounding terminal bar must be installed and bonded to the panelboard for the termination of feeder and branch circuit equipment grounding conductors



The equipment grounding bus is non-insulated and mounted inside the panelboard and connects directly to the metal enclosure.

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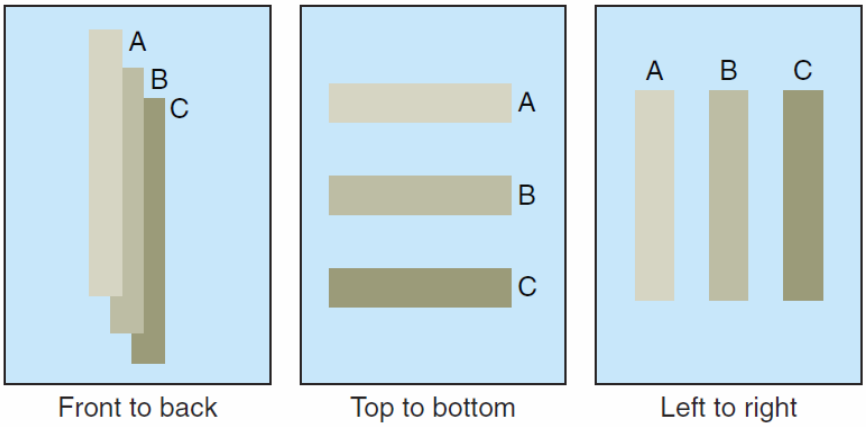
A *busbar* is a common connection for two or more circuits. Three-phase busbars are required to have phases in sequence so that an installer can have the same fixed phase arrangement.



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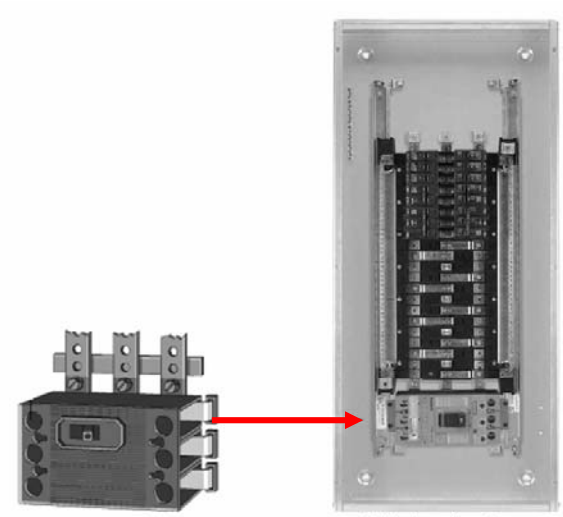
Panelboards are classified as *main breaker* or *main lug* types.

Main breaker–type panelboards have the incoming supply cables connected to the line side of a circuit breaker, which in turn feeds power to the panelboard



Main breaker type

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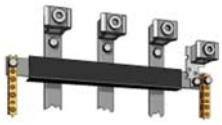
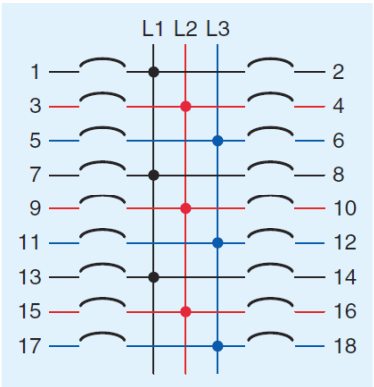
A ***main lug panelboard*** does not have a main circuit breaker. The incoming supply cables are connected directly to the busbars. Primary overload must be externally provided.

Main Lug Type



Normally panelboard circuit terminals are required to be labeled or to have a wiring diagram.



Typical terminal numbering

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MOTOR CONTROL CENTERS (MCCS)

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At times a commercial or industrial installation will require that many motors be controlled from a central location called a *motor control center.*

A motor control center is a modular structure designed specifically for plug-in type motor control units.

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The motor control center is an assembly of primarily motor controllers having a *common bus*.

They support and house control units, a common bus for distributing power to the control units, and a network of wire trough for accommodating incoming and outgoing load and control wires.

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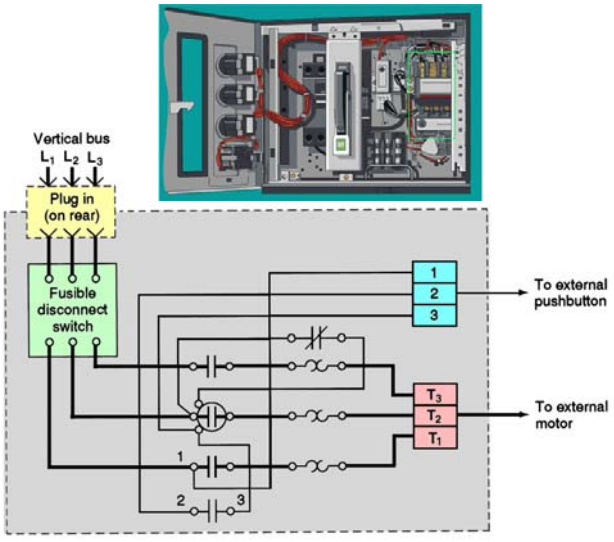
Each unit is mounted in an individual, isolated compartment having its own door.



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MCCs are not limited to housing just motor starters but can typically accommodate many unit types.

Lighting contactor

Metering unit

Programmable logic controller (PLC)

Variable-frequency drive

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Full-voltage reversing starter

Full-voltage nonreversing starter

Soft starter

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