

Ch. 12 Electrical Systems – Power Supply

Definitions

- ✓ Ampere: the unit flow of electrons in a conductor equal to 6.251×10^{18} electrons passing a given section in 1 second
- ✓ Energy: the product of power and time, also called work
- ✓ Impedance: the resistance in an alternating current (AC) circuit measured in ohms
- ✓ Ohm: the unit of resistance in an electrical circuit
- ✓ Power factor: the phase difference between voltage and current in an alternating current circuit
- ✓ Reactance: part of the electrical resistance in an alternating current circuit caused by inductance and capacitance
- ✓ Volt: the unit of electromotive force or potential difference that will cause a current of 1 ampere to flow through a conductor whose resistance is 1 ohm
- ✓ Watt: the unit of electrical power

Basic Relationship

- ✓ Electricity is the energy caused by the flow of electrons. A basic circuit consists of a conductor, the actual flow of electrons (current), an electric potential difference to cause the electrons to move (voltage), and some type of resistance to the flow of electrons.
- ✓ Ohms law: $V=IR$
 - V = voltage
 - I = current
 - R = resistance
- ✓ $W (P) = VI$
- ✓ Sine Wave of AC
 - ✓ The amplitude of the wave represents the voltage, and the distance between peaks is one cycle. In the US, alternating current is produced at a frequency of 60 cycles per second, or 60 Hz. In Europe and other countries the frequency is 50 Hz.
 - ✓ In AC circuits, resistance is known as impedance, which comprises resistance and reactance and causes a phase change difference between voltage and current. The difference is represented by the power factor (PF) and can be a significant factor in calculating power in an AC circuit.

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- ✓ Two types of electrical circuits: series circuit, parallel circuit. In a series circuit the current, I , remains constant throughout the circuit, but the voltage potential changes, or drops, across each load. In a parallel circuit, the voltage remains the same, but the current is different across each load.
- ✓ Basic circuit types

Materials

- ✓ The basic material of electrical system is the conductor. The sizes of conductors are based on America Wire Gauge (AWG) and thousand circular mil (MCM) designations.
- ✓ Cable larger than 4/0 gauge is designated with the MCM nomenclature. A circular mil is a derived area measurement representing the square of the cable diameter in thousands of an inch (mils).
- ✓ There are many different types of conductors and insulating materials. Two basic conductors are copper and aluminum.

Aluminum	Copper
<ul style="list-style-type: none">■ Aluminum must be larger than copper to carry the same amperage, but it is lighter and generally has a lower installation cost in large sizes.■ Requires special care in installation because joints can loosen and oxide can form that can cause resistance and overheating.■ Limited to primary circuits that are installed by skilled workers.	<ul style="list-style-type: none">■ Copper is more cost effective in the small- and medium-size wire and cable sizes.

- ✓ Nonmetallic sheathed cable, also known by the trade name “Romex,” consists of two or more plastic-insulated conductors and ground wire surrounded by a moisture-resistant plastic jacket. This type of cable can be used in wood-frame residential buildings and those not exceeding three stories, as long as it is used with wood studs and protected from damage by being concealed behind walls and ceilings. Because it does not require conduit, it is inexpensive to install.

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- ✓ Flexible metal clad cable, also known by the trade name “BX,” consists of two or more plastic-insulated conductors encased in a continuous spiral-wound strip of steel tape. It is often used in remodeling work because it can be pulled through existing spaces within a building.
- ✓ The most common type of wire and cable is a single conductor covered with thermoplastic or rubber insulation. Several different types are available for different voltages and service conditions. This cable must be placed in metal conduit or other approved types of carriers.
- ✓ When high currents are involved, the use of very large cables becomes expensive and awkward to tap into for transformers and branch circuits. Instead, rectangular bars of copper, called busbars, are used. When several busbars are assembled in a special metal housing, it is called a busduct or busway.
- ✓ Conduit supports and protects the wiring, serves as a system ground and protects surrounding construction from fire if the wire overheats or shorts.
- ✓ There are three types of rigid steel conduit: rigid steel conduit, intermediate metal conduit (IMC), and eclectic metallic tubing (EMT).

rigid steel conduit	intermediate metal conduit (IMC)	eclectic metallic tubing (EMT)
It is the heaviest and is connected to junction boxes and other devices with threaded fittings.	It has thinner walls but the same outside diameter as rigid steel conduit. It is also installed with threaded fittings.	It is the lightest of the three and is installed with special pressure fittings because it is too thin to thread. It is easier and faster to install but cannot be used in hazardous areas.

- ✓ Flexible metal conduit is also available to minimize vibration transmission from equipment to the structure and for areas where installation of rigid conduit is not possible. It is commonly referred to as flex.
- ✓ The purpose of limiting the number of conductors is to prevent damage from trying to pull too many conductors through a small space and to control the heat buildup inside the conduit.
- ✓ The National Electrical Code places certain limits on the length, number, and radius of bends in a conduit between pull boxes to prevent damage to the conductors and make pulling the conductors easier. In most cases, there can be no more than four 90-degree bends between pull boxes.
- ✓ There are two varieties of underfloor raceways: underfloor ducts and cellular metal floor.

underfloor ducts	cellular metal floors
They are proprietary steel raceways cast into	They use the same basic concept but are

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<p>a concrete floor at regular spacing. Feeder ducts run perpendicular to the distribution ducts and carry power and signal wiring from the main electrical closet to each distribution duct. Preset inserts are placed along the distribution ducts at close intervals, and these are tapped wherever an outlet or telephone connection is required.</p>	<p>actually part of the structural floor. They are essentially metal decking designed for use as cable raceways.</p> <p>Cellular floors differ from underfloor ducts in that the cells are closer together.</p>
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- ✓ Under-carpet wiring is thin, flat, protected wire that can be laid under carpet without protruding. However, it must be used with carpet tiles so that it is readily accessible. Under-carpet wiring connects pedestals in the middle of the room that contain electrical outlet and telephone connections to junction boxes in nearby walls, where the wiring is connected to standard conduit-enclosed cable.

Power Supply

- ✓ The most common form of electrical energy used in buildings is alternating current. Direct current is used for some types of elevator motors and for low-voltage applications such as signal systems, controls, and similar equipment.

Primary Service

- ✓ Service may be either overhead or underground. Underground service is more expensive but avoids the clutter of overhead wires and protects the lines from snow, wind, and other potentially damaging conditions. When overhead service is provided to smaller projects, the service cable is connected to a weatherhead at least 12 feet above the ground. This is part of the conduit that leads to the meter and distribution panel.
- ✓ The most common for residences and very small buildings is 120/240-volt, single-phase, three-wire. It is used where the actual load does not exceed 80 amps, although minimum service is considered 100 amps.

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- ✓ A system often used for larger buildings is the 120/208-volt, three-phase, four-wire system. It is frequently used because it allows use of a variety of electrical loads.

- ✓ For larger buildings, a 277/480-volt, three-phase, four-wire system is used. The advantages to this system include smaller feeders, smaller conduit, and smaller switchgear. This is possible because of the higher voltages used and therefore the smaller currents the equipment has to carry.
- ✓ For very large commercial buildings and factories with a great deal of machinery, 2400/4160-volt, three-phase, four-wire systems are available.

Transformer

- ✓ Transformers are used to change alternating current voltages, either up or down. In most cases, power is supplied to a building at high voltage because the lines can be smaller and there is less voltage drop. The building owner must supply the transformer to provide one of the types of service.
- ✓ Transformers generate a great deal of heat

Metering and Load control

- ✓ Metering must be provided at the service entrance to a building to allow the utility company to charge for energy used.
- ✓ The most common meter is the watt-hour meter. This registers the use of power over time in kilowatt-hours. The meter is placed on the incoming power line in front of any master service switch so that it can operate continuously.
- ✓ Charge on peak demand
- ✓ Most utility companies make charges based on the maximum interval demand, the average amount of energy used in a certain time period, such as 15 or 30 minutes. The ratio of the average power used to the maximum power demand is called the load factor. A low load factor implies an inefficient use of energy and a high demand charge.

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- ✓ From the user' s point of standpoint, a building' s electrical system should be designed to avoid peak use of electricity. There are several ways of doing this, which are called load control. Other terms used include load shedding, peak demand control, and peak load regulation.
- ✓ Manual and automatic control devices are available to accomplish the load control.
- ✓ Load shedding: with automatic load shedding, a device automatically monitors the use of energy, and when a certain point is reached it shuts off nonessential electrical loads.
- ✓ Load scheduling can also be used if the energy consumption characteristics of the building are known. With this method, different electrical loads are automatically scheduled to operate at different times to control the peak demand.

Primary Distribution

- ✓ For large buildings, a central electrical distribution center is required. Called the switchgear, this center consists of an assembly of switches, circuit breakers, and cables or busducts that distribute power to other parts of the building. A transformer and metering are also often included with the switchgear.
- ✓ Power coming thru the meter and transformer is split into separate circuits, each with a master switch and circuit breaker to protect the circuit from overload or short circuits. From the switchgear, power is distributed to substations for further transforming and distribution, to motor control centers, to elevator controls, and to individual panel boxes as part of the secondary distribution system.

Secondary Distribution and Branch Circuits

- ✓ Secondary distribution involves the typical lower voltage of 120 volts, 240 volts, and 277 volts. Secondary distributions is made with wires in conduit, various types of underfloor raceways, or flexible cabling systems.
- ✓ Each circuit is protected with circuit breakers in the panel board.
- ✓ There are two important kinds of protection for electric circuits: grounding and ground fault protection. All new construction is grounded with a separate wire in addition to the hot and neutral wiring of each circuit. One of the primary purpose for providing a ground is to prevent a dangerous shock if someone touches an appliance with a short circuit and simultaneously touches a ground path such as a water pipe.
- ✓ A ground fault can create other problems, because the current required to trip a circuit breaker is high and small leaks of current can continue unnoticed until someone receives a dangerous shock or a fire develops.
- ✓ Ground fault interrupters (GFIs) are devices that detect small current leaks and disconnect the hot wire to the circuit or appliance. GFIs can be part of a circuit breaker or installed as an outlet.

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Wiring Devices

- ✓ Receptacle: duplex receptacle, duplex outlet – most common receptacle, also called convenience outlet (because it is designed for normal use by building occupants for portable lamps, clocks, electronic devices, appliances, and similar devices that operate at 120 volts.
- ✓ GFCI (Ground Fault Circuit Interrupters)
- ✓ Electric devices that are not plugged in but connected to the building circuits in junction boxes are said to be hard wired.
- ✓ A convenient outlet has two holes to receive the prongs of the plug supplying power and a third hole for the grounding prong. The grounding pole is connected to a green wire that is part of the wiring in the conduit. Alternately, the grounding pole of the outlet may be connected to the metal conduit that acts as the system ground.
- ✓ Split-wired receptacles can be installed so that one outlet is always energized but the other is controlled from a wall switch. This allows floor lamps and other devices that normally plug in to be controlled with a switch.
- ✓ Outlets are normally mounted vertically from 12 to 18 inches above the floor, although 15 in mounting height is required for forward reach accessibility for persons in wheelchairs.
- ✓ In residential construction, outlets must be located no more than 12 feet apart, so that no points is more than 6 feet from an outlet.
- ✓ Most residential convenience outlet circuits are 15 amps, but at least two 20-amps appliance circuits must be provided for the kitchen, pantry, breakfast room, and dining room.
- ✓ Outlets within 6 feet of a sink must be of the GFCI type.
- ✓ Switches are used to control power to lights, receptacles, and other electric devices. The most common is the toggle type, which simply switches on or off with a toggle, or lever.
- ✓ Other type: rocker, push, and key
- ✓ When one switch controls a light or other device is called a two-way switch. When two switches are used to control the same device they are three-way switches. Four-way switches are used to control the same device from three or more locations.
- ✓ Low-voltage switching is also available. With this system, individual switches are operated on a 24-volt circuit and control relays that provide the 120-volt switching.
 - Advantages over line-voltage switching:
 - The same light or device can be controlled from several positions that are remote from each other.
 - A central control station can be set up to monitor the entire system and override local control.
 - Control devices such as timers and energy management systems can be wired to override local control.

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- For large installations that require flexibility of control, the low voltage wiring and switches are less expensive than installing the same scope of line-voltage wiring devices.

Emergency Power Supply

Emergency power	Standby power
<ul style="list-style-type: none">✓ Emergency power is required for electrical systems that relate to the safety of occupants or community needs. This includes such things as exit lighting, alarm systems, elevators, telephone systems, and fire pumps, as well as equipment that could have life-threatening implications if power were lost, such as some medical equipment.✓ It is supplied by generators or batteries.✓ Expensive to install and must be maintained and checked periodically for proper operation.	<ul style="list-style-type: none">✓ Standby power provides electricity for functions that the building owner requires to avoid an interruption in business. This often includes computer operations or industrial process.

Ch. 12 Electrical Systems – Lighting Fundamentals

Light and Vision

- ✓ Light is defined as visually evaluated radiant energy. Visible light is a form of electromagnetic radiation with wave lengths that range from about 400 nanometers (10^{-9} meters) for violet light to about 700 nanometers for red light.
- ✓ When light strikes a surface it can be transmitted, reflected, or absorbed. If a material is transparent, such as window glass, most of the light is transmitted. The ratio of the total transmitted light to the total incident is the transmittance or coefficient of transmission, expressed as percentage. (clear glass – 85%, frosted glass – 70-85%)
- ✓ The remainder of the light is either reflected or absorbed. Material that allows the transmittance of light but not of a clear image is said to be translucent.
- ✓ In clear materials, light is refracted, or bent slightly, as it passes through the material. Refraction is the principle on which lenses are made, so light passing through the lens is bent toward the thicker part of the lens.
- ✓ If a material allows no light no pass through, it is opaque and all incident lights is either reflected or absorbed. A flat black material absorbs most of the incident light. A white material reflects most incident light. Like transmittance, the ratio of the total reflected light to the total incident light is the reflectance or reflectance coefficient, also expressed as a percentage.
- ✓ How light is reflected depends on the finish of the material it is striking.
 - Specular reflection results from a smooth, polished surface, such as mirror. The angle of incidence equals the angle of reflection.
 - Diffuse reflection results from a uniformly rough surface. It appears uniformly bright, and the image of the source cannot be seen.
 - Combined specular and diffuse surfaces appear to be brighter at the point where the source is shining than in the surrounding areas.
 - Diagram:

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- ✓ Light is perceived through the eye and with the brain. The amount of light entering the eye is controlled by the iris (brightness). The lens focuses the images (upside down) on the retina, where the light stimulates cells that send messages to the brain, where they are interpreted. The retina contains two types of cells: the cones and the rods. The cones are cells located near the fovea, or central portion of the retina. They are shaped like cones and are extremely sensitive to detail and color. On the remainder of the retina are the cells shaped like rods. The rods are extremely sensitive to light and motion. They are not as good as the cones in discriminating color or detail.

Definitions

- ✓ Candlepower: the unit of luminous intensity approximately equal to the horizontal light output from an ordinary wax candle.
- ✓ Illuminance: the density of luminous flux incident on a surface in lumens per unit area. One lumen uniformly incident on 1 square foot of area produces an illuminance of 1 footcandle.
- ✓ Lumen: the unit of luminous flux equal to the flux in a unit solid angle of 1 steradian from a uniform point source of 1 candlepower. (the rate flow of visible light per unit time)
- ✓ Luminance: the luminous flux per unit of projected area and unit solid angle leaving surface, either reflected or transmitted. (footlambert)
- ✓ Luminous intensity: the solid angular flux density in a given direction measured in candlepower or candelas.

Light Levels

- ✓ Good lighting: providing both the proper quantity and proper quality of light to perform a task
- ✓ The Illuminating Engineering Society (IES) has established a method for determining a range of illumination levels in footcandles (lux) appropriate to particular design conditions.

Design Consideration

- ✓ The quality of light is just as important as the amount of light provided. Important considerations are glare, contrast, uniformity, and color.
- ✓ Two types of glare: direct and reflected
 - Direct glare results when a light source in the field of vision causes discomfort and interference with the visual task. Not all visible light sources cause direct glare problems. The extent of the problem depends on the brightness of the source, its position, the background illumination, and the adaptation of the eye to the environment.
 - In order to evaluate the direct glare problem, the visual comfort probability (VCP) factor was developed. This factor is the percentage of normal observers who may be expected to

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experience visual comfort in a particular environment with a particular lighting situation.

- For most situations, the critical zone for direct glare is in the area above a 45-degree angle from the light source. This is because the field of vision (when looking straight ahead) includes an area approximately 45 degrees above a horizontal line. Many direct glare problems can be solved by using a luminaire out of the offending field of view.
- Reflected glare occurs when a light source is reflected from a viewed surface into the eye. If it interferes with the viewing task, it is also called veiling reflection. The effect of reflected glare is to decrease the contrast of the task and its background.
- Veiling reflections are a complex interaction of light source and brightness, position of the task, reflectivity of the task, and position of the eye. One of the simplest ways to correct veiling reflections is to move the position of the task or the light source. Because the angle of incidence is equal to the angle of reflection, this is easy to calculate. It is not always possible, however, because the exact use of a room and its furniture arrangement are not always known. Another approach is to provide general background illumination and specific task lighting, the position of which can be controlled by the user.
- ✓ Contrast is the difference in illumination level between one point and nearby points. Because people see by contrast, it is vital to the quality of an environment. (a printed word is visible...)
- ✓ Too much contrast can be detrimental. It is difficult to see fine detail on a small, dark object when the object is viewed against a bright background because the eye has adapted (the iris of the eye is smaller) to the brighter background and cannot admit enough light to see the darker object. The eye adapts by opening and closing the iris, but this causes eye strain and fatigue.
- ✓ Brightness ratios – 1:1/3 between the task and adjacent surroundings, to 1:1/5 between the task and more remote darker surfaces, and to 1:10 between the task and more remote lighter surfaces.

LIGHT SOURCES

- ✓ Incandescent, fluorescent, high-intensity discharge
- ✓ Efficacy is the ratio of luminous flux emitted to the total power input to the source and is measured in lumens per watt. It is an important measure of the energy efficiency of a light source.

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Incandescent

✓ An incandescent lamp consists of a tungsten filament placed within a sealed bulb containing an inert gas. When electricity is passed through the lamp the filament glows, producing light.

✓ Lamp shapes

A arbitrary (standard shape)		PS pear shape, straight neck	
P pear shape		S Straight	
G globe		T tubular	
PAR parabolic aluminized reflector		R reflector	
ER elliptical reflector		MR miniature reflector	

✓ Incandescent lamps are inexpensive, are compact, are easy to dim, can be repeatedly started without a decrease in lamp life, and have a warm color rendition. In addition, their light output can be easily controlled with reflectors and lenses.

✓ Their disadvantages include low efficacy, short lamp life, and high heat output. The combination of low efficacy and heat production makes incandescent lamps undesirable for large, energy-efficient installations.

✓ Another type of incandescent lamp is the tungsten halogen. Light is produced by the incandescence of the filament, but there is a small amount of a halogen, such as iodine, or bromine, in the bulb with the inert gas. Through a recurring cycle, part of the tungsten filament is burned off as the lamp operates, but it mixes with the halogen and is redeposited on the filament instead of on the wall of the bulb as in standard incandescent lamps. This results in longer bulb life, low lumen depreciation over the life of the bulb, and a more uniform light color.

✓ Reflector (R) and parabolic aluminized reflector (PAR) lamps contain a reflective coating built into the lamp. This increases the efficiency of the lamp and allows more precise beam control. Both are available in flood (wide) and narrow (spot) beam dispersal patterns. PAR lamps are made with heavier glass and are more suitable for outdoor use.

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- ✓ Elliptical reflector (ER) lamps are an improved version of the R lamps. They provide a more efficient throw of light from a fixture by focusing the light beam at a point slightly in front of the lamp before it spreads out. Its spread is slightly smaller than that of the R lamp. The design is used for downlights with deep baffles or with small openings so that less of the light's output is trapped in the fixture.
- ✓ Low-voltage miniature reflector (MR) lamps are small tungsten-halogen lamps that are available in a wide variety of wattages (20 to 75W) and beam spreads.

Fluorescent

- ✓ Fluorescent lamps contain a mixture of an inert gas and low pressure mercury vapor.
- ✓ 3 types: preheat, rapid start, and instant start
- ✓ Preheat lamps have been supplanted by rapid start types. These types maintain a constant, low current in the cathode that allows it to start within about 2 seconds. Instant start lamps use voltage high enough to start the arc in the tube directly without preheating of the cathode.
- ✓ All fluorescent lamps have a ballast, a device that supplies the proper starting and operating voltages to the lamp as well as limiting the current. Because ballasts produce noise and heat, their correct selection is critical for a successful lighting design. Ballasts are sound rated by letters. Class A is appropriate for spaces with the lowest ambient noise levels, and Class F is suitable for noisy environments.
- ✓ The electronic ballast: lower power consumption, silent operation, ease of dimming, and reduced flicker of the lamp
- ✓ Lamps are produced in tubular shapes. They are normally straight, but U-shape and circular lamps are also produced.
- ✓ i.e.) F40T12WW/RS – fluorescent lamp, 40 watts, tubular, 12/8 inch in diameter, warm white color, with a rapid start circuit
- ✓ 4 feet in the most common length
- ✓ Fluorescent lamps have a high efficacy (about 80 lumens per watt), relatively low initial cost, and long life. They come in a variety of color temperatures. They can also be dimmed, although fluorescent lamp dimmers are more expensive than their incandescent counterpart. Because fluorescent lamps are larger than incandescents, it is more difficult to control them precisely, so they are usually more suitable for general illumination.

High-Intensity Discharge

- ✓ High-intensity discharge (HID) lamps include mercury vapor, metal halide, and high- and low-pressure sodium.
- ✓ In the MERCURY VAPOR LAMP, an electric arc is passed through high pressure mercury

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vapor, which causes it to produce both ultraviolet light and visible light, primarily in the blue-green band. For improved color rendition, various phosphors can be applied to the inside of the lamp to produce more light in the yellow and red bands. Mercury lamps have a moderately high efficacy, in the range of 30 to 50 lumens per watt depending on voltage and the type of color correction included.

- ✓ METAL HALIDE LAMPS, which produce about 50 to 100 lumens per watt, are similar to mercury except that halides of metals are added to the arc tube. This increases the efficacy and improves color rendition but decreases lamp life.
- ✓ HIGH-PRESSURE SODIUM (HPS) lamps produce light by passing an electric arc through hot sodium vapor. The arc tube must be made of a special ceramic material to resist attack by the hot sodium. HPS lamps have efficacies from 80 to 140 lumens per watt, making them one of the most efficient lamps available. Color rendition is also acceptable for a wide variety of applications.
- ✓ LOW-PRESSURE SODIUM lamps have an even higher efficacy, about 150 lumens per watt, but produce a monochromatic light of a deep yellow color. Therefore, they are suitable only for uses where color rendition is not important, such as street lighting.

LIGHTING DESIGN

- ✓ Lighting designed to minimize energy use
- ✓ Lighting design is dependent on the fixtures, or luminaires, that are available to provide light.
- ✓ One of the basic elements of every luminaire is the way it delivers light to the space. This is shown graphically with a candlepower distribution curve, which shows how much light is output at all angles from the luminaire.

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Lighting systems

- ✓ Direct lighting systems provide all light output on the task. A recessed fluorescent luminaire is an example of direct lighting. Semidirect systems put a majority of the light down and a small percentage toward the ceiling. Fixtures for this type of system must be surface mounted or suspended. Indirect systems throw all the light toward a reflective ceiling where it illuminates the room by reflection.

direct	semidirect	direct-indirect
general diffuse	semi-indirect	indirect

- ✓ Task-ambient: This approach to lighting design recognizes that it is inefficient to try to illuminate an entire room to the level required for individual tasks scattered around the room.

LUMINAIRE TYPES

- ✓ Surface-mounted fixtures are among the most commonly used types for residential and commercial buildings. The luminaire is directly attached to the finished surface of the ceiling, directing all or a majority of the light into the room. These fixtures are used where there is not sufficient space above the ceiling to recess a fixture or where fixtures are added after the ceiling has been constructed.
- ✓ Recessed fixtures are used in both residential and commercial construction and include both incandescent and fluorescent lights.
- ✓ Luminaires dropped below the level of the ceiling are called suspended fixtures. These include direct incandescent or fluorescent fixtures, track lighting, indirect systems, Chandeliers, and

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other types of specialty lights. Suspended mounting is required for indirect lighting systems. The fixture must be located far enough below the ceiling to allow for the proper spread of light to bounce off the surface.

- ✓ Wall-mounted luminaires can provide indirect, direct-indirect, or direct lighting. For general illumination, sconces direct most of the light toward the ceiling. Cove lighting can also be mounted on a wall near the ceiling and will indirectly light either the ceiling or the wall depending on how it is shielded.
- ✓ Furniture-mounted lighting is common with task-ambient systems. Individual lights are built into the furniture above the work surface to provide sufficient task illumination, whereas uplighting is provided by lights either built into the upper portions of the furniture or as freestanding elements.
- ✓ Freestanding light fixtures include items such as floor lamps.
- ✓ Accessory lighting includes table lights, reading lamps, and fixtures that are intended for strictly decorative lighting rather than for task or ambient lighting.

QUALITY OF LIGHT

- ✓ Every lamp has a characteristic spectral energy distribution. This is a measure of the energy output at different wavelengths, or colors.
- ✓ Lower temperature, such as 3100° K are relatively warm colors like that of a warm white fluorescent light. Higher color temperature, such as 5000 to 6000° K, are cool colors with a high percentage of blue.
- ✓ Sources are also rated with a number known as the color rendering index (CRI). This is a measure of how closely the perceived colors of an object illuminated with a test source match the colors of the object when it is illuminated with daylight of the same color temperature.

Lighting Calculations

- ✓ Determining the quantity of light in a space
- ✓ For point source of light, the illumination on a surface varies directly with the luminous intensity of the source and inversely with the square of the distance between the source and the point.

If the surface is perpendicular to the direction of the source:

$$E = I/d^2$$

For surfaces that are not perpendicular, $E = I \cos \theta / d^2$

- ✓ Zonal cavity method
 - The lumen output of the lamps used
 - The number of lamps in each luminaire

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- The efficiency of the luminaire. The rating given a particular luminaire is known as the coefficient of utilization (CU) and represents the fact that not all of the lumens produced by the lamps reach the work surface.
- The light loss factor (LLF). This is a fraction that represents the amount of light that will be lost due to several additional factors. Among these are lamp lumen depreciation, which is light loss with age, and luminaire dirt depreciation, which is light loss due to accumulated dirt on lamps based on the kind of environment in which they operate.
- Number of luminaires =
$$\frac{(\text{footcandles})(\text{area of room})}{(\text{number of lamps})(\text{lumen per lamp})(\text{CU})(\text{LLF})}$$

Energy Budgets

- ✓ 2.3 watts per square foot is often considered a maximum.

EMERGENCY LIGHTING

- ✓ Emergency lighting is required in exit stairs and corridors as well as in certain occupancies such as places of assembly, educational facilities, hazardous locations, and other places where occupancy loads exceed a given number. The usual minimum lighting level required is 1 footcandle at the floor level.

Ch. 12 Electrical Systems – Signal and Safety Alarm Systems

- ✓ Contemporary buildings contain a complex variety of signal and communication systems. These are low-voltage circuits connecting various types of devices that make it possible for the building to function properly and that protect the occupants.

Communication systems

- ✓ Communication systems include telephone systems, intercom systems, paging and sound systems, television, closed circuit television (CCTV), and most recently, computer systems, as well as local area networks (LANs) that allow the sharing of data on several computers within one building or in a complex of buildings.
- ✓ Telephone systems

Security Systems

- ✓ Security systems include methods for detecting intruders, preventing entry, controlling access to secure areas, and notifying authorities in the event of unauthorized entry or other emergencies.
- ✓ Intrusion detection. Security derived from intrusion detection devices can be classified into three types: perimeter protection, area or room protection, and object protection.
- ✓ Perimeter protection secures the entry points to a space or building. These include doors, windows, skylights, and even ducts, tunnels, and other service entrances.
 - Magnetic contact
 - Glass break detectors
 - Window screens
 - Photoelectric cells
- ✓ Area or room protection senses when someone is in a room or area within the device's field of coverage. These devices provide the advantage of warning of unauthorized entry when perimeter sensors have not been activated.
 - Photoelectric beams
 - Infrared detectors
 - Audio detectors
 - Pressure sensors
 - Ultrasonic detectors
 - Microwave detectors
- ✓ Object protection is used to sense movement or tampering with individual objects such as safes, artwork, file cabinets, or other equipment.
- ✓ Access control. Access to secure areas can be controlled with a number of devices. The simplest in the traditional mechanical lock.

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- Card readers are common electronic access control devices.
- Numbered keypads
- Electric lock, which retracts the bolts when activated from the secure side of the door. Electric locks require an electric hinge or other power-transfer device to carry the low-voltage wiring from the control device to the door and then to the lock.
- Electric strikes are also used. These replace the standard door strike and consist of a movable mechanism that is mortised into the frame. The latch bolt is fixed from the secure side of the door. On activation, the electric strike retracts, allowing the door to be opened. On the inside, the latch bolt can be retracted by mechanical means with the lever handle.
- ✓ Notification systems.

Fire Detection and Alarms

- ✓ 4 Types of fire detection devices:
 - The ionization detector: it responds to products of combustion-ionized particles rather than smoke. They are not appropriate where fires may produce a lot of smoke but few particles.
 - Photoelectric detector: respond to smoke, which obscures a light beam in the device. These are useful where potential fires may produce a great deal of smoke before bursting into flames.
 - Rise-of-temperature devices detect the presence of heat and can be set to trip an alarm when a particular temperature is reached in the room. The major disadvantage is that flames must usually be present before the alarm temperature is reached.
 - Flame detectors