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LEARNING MODULE


College: **CIE**
 Department: **Technical Arts**
 Program: **BSIE**
 Major: **Industrial Arts**
 Course: **IA3 Fundamentals of Electrical and Electronics Technology**


Module 3 Title: Performing the safe and appropriate identification, selection, installation, maintenance, and management of equipment, devices and materials.

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		Compiled by: Prof. Noreen Z. Rejano	Issued by:	1
			Revision No.:	


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MODULE TITLE:	Perform the safe and appropriate identification, selection, installation, maintenance, and management of equipment, devices and materials.
MODULE DESCRIPTION:	This module will aid in developing and improving the basic knowledge of every student about certain concepts and attitudes required in performing the safe and appropriate identification, selection, installation, maintenance, and management of equipment, devices and materials.. You are required to go through a series of learning activities in order to complete each of the learning outcomes of the module. In your learning outcome there are Information Sheets, Job Sheets, Operation Sheets and Activity Sheets . Do these activities on your own and answer the Self-Check at the end of each learning activity.
Nominal Duration:	60 hours (2 weeks)
Course Outcomes	Perform the safe and appropriate identification, selection, installation, maintenance, and management of equipment, devices and materials.
LEARNING OUTCOMES:	<p>Upon completion of this module, you must be able to:</p> <p>LO 3.1 Correctly identify different types of conductors and correct wiring accessories</p> <p>LO 3.2 Layout and install raceways</p> <p>LO 3.3 Identify different type of Electrical conduit</p> <p>LO 3.4 Identifying Correct Quantity of Electrical Boxes and Fittings</p> <p>LO 3.5 Interpreting Diagrams with Outlets</p> <p>LO 3.6 Classify switches based on their uses and function</p>
ASSESSMENT CRITERIA:	Refer to the assessment criteria of learning outcomes 3.1 – 3.6 of this module.

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LEARNING OUTCOME 3.1	Correctly identify different types of conductors and correct wiring accessories
CONTENT: <ol style="list-style-type: none"> 1. General house wiring guideline in accordance with PEC 2. Conductors and Insulators 3. Different Types of Cables 	
ASSESSMENT CRITERIA: <ol style="list-style-type: none"> 1. Identify different conductor and insulators 2. Compare and contrast uses and application of different types of cables 3. explain the importance of Philippine Electrical Code in wiring practices; 4. discuss wires and cables and realize the importance of using the right size in wiring application; 5. identify the different insulations for wires and cables using the letter codes; 6. Apply knowledge gain in ampacity of electrical conductor 	
CONDITION: <p>Students/Trainees must be provided with the following:</p> <ol style="list-style-type: none"> 1. WORKPLACE/LOCATION Computer, Laptop, Android Cellphone, MS Teams Account, Email Address 2. TOOLS, ACCESSORIES AND SUPPLIES White board Power Point presentation Marker 3. TRAINING MATERIALS Copy of the Module 1 Bond Paper Rubrics Criteria 	

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ASSESSMENT METHOD:

Hands-on Activity


Evaluation of Outputs (Portfolio)


Written Test

Demonstration

Questioning

Observation

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Information Sheet 3.1.1

General house wiring guideline in accordance with PEC

Learning Objectives:

After reading this INFORMATION SHEET, you should be able to:


1. Elaborate the general house wiring guidelines in accordance with PEC
2. Explain the concept of wire ampacity
3. Apply knowledge learn on house wiring activity
4. Follow safety precaution while performing wire splices


Philippine Electrical Code (PEC)

The Philippine Electrical Code or PEC is the standard of safety in all electrical practices in the Philippines. So important in the field and use of electricity, it is included in the Philippine Law under PD 442 otherwise known as “The Labor Code of the Philippines”. Rule No. 1000 of this Law we find the Occupational Safety and Health Standards.

OSH Rule No. 1001 states the purpose and scope

- The objective of this issuance is to **protect** every workingman against the dangers of injury, sickness or death through safe and healthful working conditions, thereby assuring the conservation of valuable manpower resources and the prevention of loss or damage to **lives and properties**, consistent with national development goals and with the State’s commitment for the total development of every worker as a complete human being.

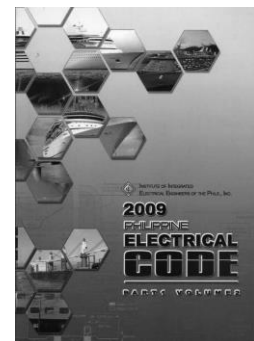
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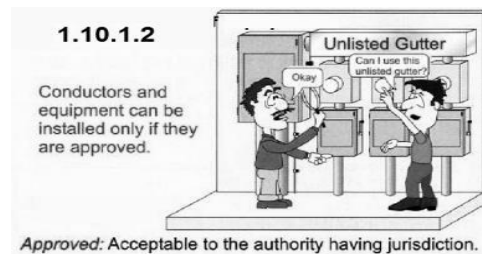
To ensure the protection of lives and properties, under the OSH in Rule No. 1211 we read:


- ✓ **The Philippine Electrical Code** is hereby adopted, and the standards contained therein shall be considered **safety standards** to the extent that they safeguard any person employed in any workplace and control the practice of electrical engineering.


The primary objective of the *Philippines Electrical Code* is to establish basic material quality and electrical work standards for the safe use of electricity for light, heat power, communications, signaling and for other purposes. Practical safeguarding of persons and property from the hazards arising from the use of electricity. It contains provisions that are considered minimum requirements necessary for safety. Compliance therewith and proper maintenance will result in an installation that is essentially free from hazard and risk of electrical fire.



An example of wiring design rule in PEC. According to PEC Rule No. 1.10.1.2, only approved materials are to be used in electrical installation. No sub-standard materials are to be used to ensure electrical safety.



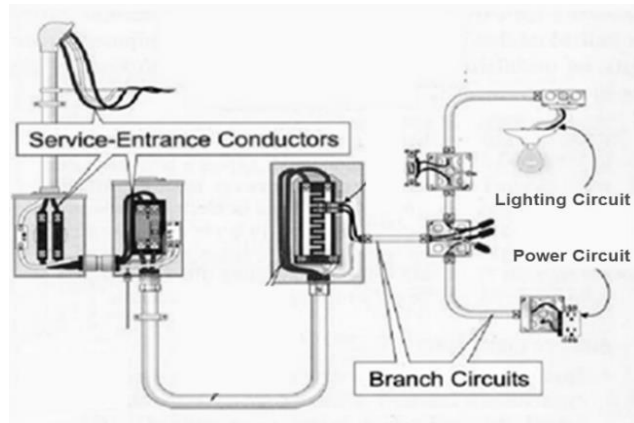
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Pic. 3

There are 3 kinds of wires used in house wiring installation as shown on Pic. 4.

- Service entrance conductor
- Wire for the lighting circuit
- Wire for the power circuit (convenience outlets)




According to the PEC, standard sizes of wire must be used in all electrical installation. Lower than the minimum standard will be a violation of this Code and might result to unnecessary accident.


Allowable Wire Standard in House Wiring Installation

Wires Used For:	Minimum Wire Standard
Service Entrance	#8 AWG
Lighting Circuit	#14 AWG
Power Circuit	#12 AWG
Air Conditioning Unit (ACU)	# 10 AWG

Wire is sized by the American Wire Gauge (AWG) system. Wire gauge refers the physical size of the wire, rated with a numerical designation that runs opposite to the diameter of the conductors—in other words, the smaller the wire gauge number, the larger the wire diameter. Common sizes include 14-, 12-, 10-, 8-, 6-, and 2-gauge wire. The size of the wire dictates how much current can safely pass through the wire.

It is important to note that there are different sizes of wire used in house wiring due to the fact that these wires have different **ampacity**. **Wire ampacity** is the maximum amount of

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current a wire can carry before sustaining immediate or progressive deterioration. Once the allowable ampacity for the wire exceeds, the result will be electrical fire.

“Conductor size and rating shall have sufficient ampacity to carry load. They shall have adequate mechanical strength and shall not be less than the rating of the branch circuit and not less than the maximum load to be served.”


Conductor ampacity is determined by the maximum operating temperature that its insulation can withstand continuously without heating. Current flow and conductor's resistance normally generates heat. Thus, the operating temperature depends upon the amount of current flow, wire resistance, and environment


Environment refers to either *enclosed* or *open* condition on which the wire is placed.

Enclosed. Surrounded by a case, housing, fence, or wall(s) that prevents persons from accidentally contacting energized parts.

Exposed (OPEN condition as applied to wiring methods). On or attached to the surface or behind panels designed to allow access.

De-rating of Conductors Ampacity – means that, the full amount of allowable ampacity, is reduced to a certain percentage due to the environment condition it is exposed of and the number of wires placed inside the conduit.

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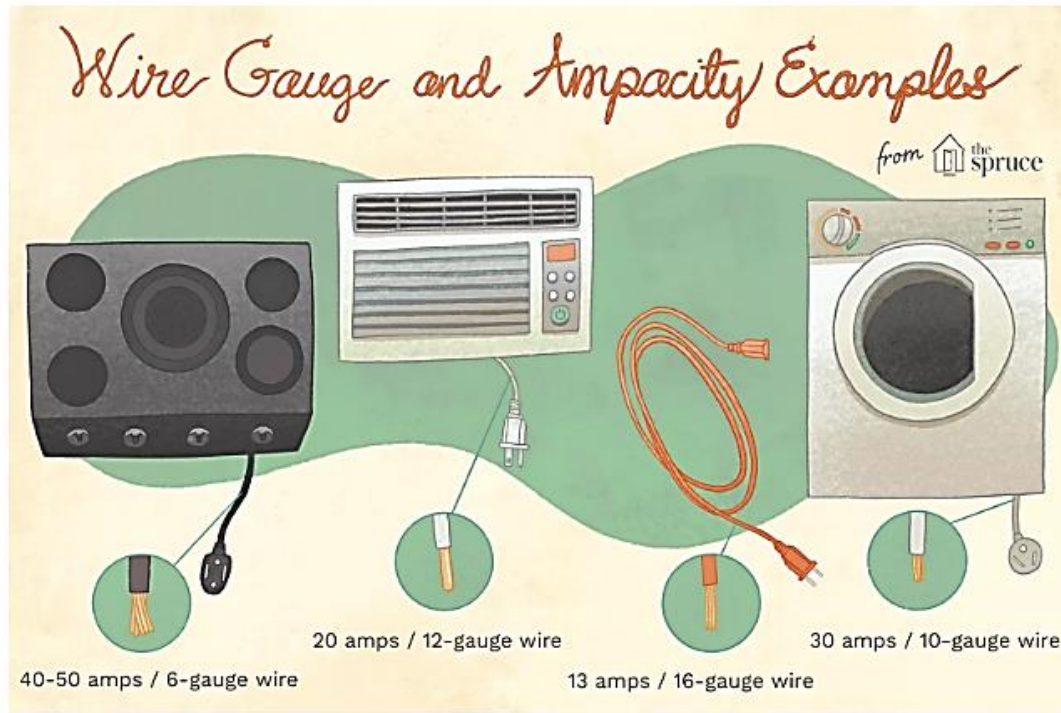




Illustration: The Spruce / Bailey Mariner

WHY WIRE GAUGE IS IMPORTANT

While circuit breakers or fuses offer good protection against overloading wires and overheating them, they are not absolute protection. Both these devices are designed to sense current overloads and to trip or "blow" before the wires can overheat to the danger point. But they are not foolproof, and it is still important to guard against exceeding the amperage rating of any given circuit by plugging too many appliances into them.

There is the potential for danger anytime a device or appliance tries to draw more power on a circuit than the wire gauge is rated for. For example, plugging a heater rated for 20 amps into a 15-amp circuit wired with 14-gauge wire poses a distinct danger. Should the circuit breaker fail to operate correctly, that heater will draw more current than the wires can safely handle, and could heat the wires to the point of melting the insulation around the wires and igniting surrounding materials.


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On the other hand, there is no danger whatsoever by plugging appliances with mild electrical loads into circuits with heavier gauge wires and a higher amperage rating. The circuit will draw the power asked for by whatever is plugged into them and no more. So, for example, running a laptop computer with a very small amperage demand on a 20-amp circuit wired with 12-gauge wire is perfectly fine.

The potential for danger is most pronounced with the use of light household extension cords. Many a household fire has occurred when a light extension cord with 16-gauge wire is used to power a heater or heating appliance of some sort. Most manufacturers will discourage the use of any extension cords with portable heaters, but if one must be used, it has to be a heavy-duty cord with a high amperage rating that matches the amperage of the appliance and of the circuit it is plugged into.

Wire Use	Rated Ampacity	Wire Gauge
Low-voltage lighting and lamp cords	10 amps	18-gauge
Extension cords (light-duty)	13 amps	16-gauge
Light fixtures, lamps, lighting circuits	15 amps	14-gauge
Kitchen, bathroom, and outdoor receptacles (outlets); 120-volt air conditioners	20 amps	12-gauge
Electric clothes dryers, 240-volt window air conditioners, electric water heaters	30 amps	10-gauge
Cooktops and ranges	40-50 amps	6-gauge
Electric furnaces, large electric heaters	60 amps	4-gauge

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Information Sheet 3.1.2

Conductors and Insulators

Learning Objectives:

After reading this INFORMATION SHEET, you should be able to:


1. Discuss conductor and insulator
2. Familiarize with tables of wires and ampacity in accordance with PEC
3. Identify letter coding of different insulator
4. Apply knowledge learn on house wiring activity
5. Follow safety precaution while performing activity


Electric Conductors are substances or materials used to convey or allow the flow of electric current. Insulators on the other hand, are substances or materials that resist the flow of electric current.

Materials considered as good electric conductors are:	
1. Silver	6. Zinc
2. Copper	7. Platinum
3. Aluminum	8. Iron
4. Nickel	9. Lead
5. Brass	10. Tin

Materials considered as not electric conductors are:	
1. Rubber	7. Latex
2. Porcelain	8. Asbestos
3. Varnish	9. Paper
4. Slate	10. Oil
5. Glass	11. Wax
6. Mica	12. Thermoplastic

Resistance as already discussed, is due to the friction between the flow of current, and the conductor as well as in insulator. There is no such thing as perfect conductor, or perfect insulator, because conductors, insulators and resistors, are resistive materials. Good conductors are those substances with extremely low resistance to current flow.

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On the other hand, good insulators are those extremely high resistance to current flow and moderate resistance to load resistor.

Based on PEC 3.10.1.2 Conductors.

Wires and cables are either a.) stranded wires and b.) Solid wires.

(b) Conductor Material. Conductors in this article shall be of aluminum, copper-clad aluminum, or copper unless otherwise specified.

3.10.1.3 Stranded Conductors. Where installed in raceways, conductors of size 8.0 mm² (3.2 mm dia.) and larger shall be stranded.

Stranded Wire – consists of a group of wires twisted to form a metallic string. The circular mil area of a stranded wire is found by multiplying the circular mil area of each strand by the total number of strand.




Cord – is the term given to an insulated stranded wire.


Mil – prior to the adoption of the Metric System (SI), all electrical wires and cables sizes were expressed in terms of AWG (American Wire Gauge). The word mil that is equal to 1/1000 of an inch was used to describe or measure a round wire diameter. If a wire has a diameter of one mil, it has a cross sectional area of one circular mil.

Electrical current is measured in **ampacity**, and each wire gauge has a maximum safe carrying capacity.



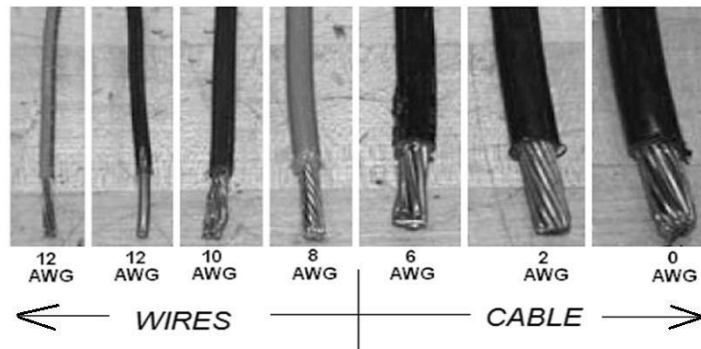
Solid wire- consists only of single conductor.

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Difference Between Wires and Cables


Wires in comparison to cables, are smaller in size. They range from 8 AWG and smaller. Cables on the other hand are larger wires ranging from 6 AWG and bigger. A wire whose size is greater than 6 AWG are considered as cable.




Minimum Size of Conductors. The minimum size of conductors shall be as shown in Table 3.10.1.5, except as permitted elsewhere in this Code.

Generally, wires and cables available in the market are measured in American Wire Gauge (AWG). In the PEC, conductor sizes are expressed in square millimeter (mm²) for stranded or in millimeter diameter (mm dia.) for solid. Table shows the equivalent measurement of wires in American Wire Gauge (AWG), millimeter (mm) and millimeter square (mm²)

Size of Wire in AWG	Size of Wire in Millimeter (mm) diameter of the wire	Equivalent Measurement in mm ²
# 14 AWG	1.628 mm	2.0 mm ²
# 12 AWG	2.052 mm	3.5 mm ²
# 10 AWG	2.590 mm	5.5 mm ²
# 8 AWG	3.263 mm	8.0 mm ²
# 6 AWG	4.115 mm	14 mm ²
# 4 AWG	5.189 mm	22 mm ²
# 2 AWG	6.543 mm	30 mm ²
# 0 AWG	8.251 mm	50 mm ²
# 00 AWG	9.265 mm	60 mm ²
# 000 AWG	10.404 mm	80 mm ²
# 0000 AWG	11.680 mm	100 mm ²

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Different sizes of wires have different ampacity depending on its size whether it be stranded or solid wire. Bigger wires have greater ampacity. Meaning, it can allow more electric current to pass through it.

The greater the ampacity, the safer is the wire from the possibility of electrical fire. However, the bigger the wire, the safer it is but more expensive.

Table 1 shows the equivalent

Ampacity of different sizes of wire.


Size of Wire in AWG	Ampacity of Copper Wire With TW, UF Insulator @ 60°C	Ampacity of Copper Wire With RH, RHW, TWH, THWN, XHHN, USE, ZW Insulators @ 75°C	Measurement in mm ²
# 14 AWG	15 A	15 A	2.0 mm ²
# 12 AWG	20 A	20 A	3.5 mm ²
# 10 AWG	30 A	30 A	5.5 mm ²
# 8 AWG	40 A	45 A	8.0 mm ²
# 6 AWG	55 A	65 A	14 mm ²
# 4 AWG	70 A	85 A	22 mm ²
# 2 AWG	90 A	110 A	30 mm ²
# 0 AWG	120 A	145 A	50 mm ²
# 00 AWG	135 A	160 A	60 mm ²
# 000 AWG	160 A	195 A	80 mm ²
# 0000 AWG	185 A	220 A	100 mm ²


INSULATORS

Electrical conductors are made in numerous types designed by letters according to the kind of insulator used. The conductor insulator serves as physical shield of the wire against heat, water and other elements of nature. Insulation is rated by voltage from 300 to 15,00 volts. If the insulation used is above its specified rating, the risk of breakdown is high which might cause short circuit and arcing that may result to fire. Ordinary conductor wires for buildings is normally rated at 300 or 600 volts.

The important labeling on individual wires relates to the wire insulation—the plastic coating that covers the metal conducting wire. The most common types of wire used in home wiring include:

- THHN
- THWN
- THW
- XHHN


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Characteristics of Selected Insulated Conductors for General Wiring

TYPE LETTER	TRADE NAME	OPERATING TEMPERATURE	APPLICATION PROVISION
<i>T</i>	<i>Thermoplastic</i>	<i>60 deg C</i>	<i>Dry Location</i>
<i>TW</i>	<i>Moisture Resistant Thermoplastic</i>	<i>60 deg C</i>	<i>Dry and Wet Location</i>
<i>THW</i>	<i>Moisture and Heat Resistant Thermoplastic</i>	<i>75 deg C</i>	<i>Dry and Wet Location</i>
<i>THHN</i>	<i>Thermoplastic Heat Resistant</i>	<i>90 deg C</i>	<i>Dry Location</i>
<i>THWN</i>	<i>Moisture and Heat Resistant Thermoplastic</i>	<i>75 deg C</i>	<i>Dry and Wet Location</i>
<i>RHW</i>	<i>Moisture Resistant Thermoplastic</i>	<i>75 deg C</i>	<i>Dry and Wet Location</i>
<i>RHH</i>	<i>Thermoset</i>	<i>90 deg C</i>	<i>Dry and Dump Location</i>
<i>XHH</i>	<i>Thermoset</i>	<i>90 deg C</i>	<i>Dry and Dump Location</i>
<i>XHHW</i>	<i>Moisture and Heat Resistant Thermoset</i>	<i>90 deg C</i>	<i>Dry and Wet Location</i>
<i>SA</i>	<i>Polyethylene Silicon Rubber</i>	<i>95 deg C</i>	<i>Dry and Dump Location</i>
<i>AVA</i>	<i>Asbestos and Varnish Cambric</i>	<i>110 deg C</i>	<i>Dry Location</i>
<i>TFE</i>	<i>Extended Polytetra Fluoro-Ethylene</i>	<i>250 deg C</i>	<i>Dry Location</i>

Table 1 – Table of Insulation

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Insulated conductors and cables used in dry locations shall be any of the types identified in this Code.

Dry and Damp Locations Insulated conductors and cables used in dry and damp locations shall be Types FEP, FEPB, MTW, PFA, RHH, RHW, RHW-2, SA, THHN, THW, THW-2, THHW, THHW-2, THWN, THWN-2, TW, XHH, XHHW, XHHW-2, Z, or ZW.

Wet Locations. Insulated conductors and cables used in wet locations shall be


Types MTW, RHW, RHW-2, TW, THW, THW-2, THHW, THHW-2, THWN, THWN-2, XHHW, XHHW-2, ZW;


Locations

Damp Location. Locations protected from weather and not subject to saturation with water or other liquids but subject to moderate degrees of moisture. Examples of such locations include partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold storage warehouses.

Dry Location. A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

Wet Location. Installations underground or in concrete slabs or masonry in direct contact with the earth; in locations subject to saturation with water or other liquids, such as vehicle washing areas; and in unprotected locations exposed to weather.

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Information Sheet 3.1.3
Different Types of Cables

Learning Objectives:

After reading this INFORMATION SHEET, you should be able to:

1. Compare and contrast uses and application of different types of cables
2. Identify the limitations of different types of cables

ARMORED CABLE (AC)


1. **Armored Cable (AC)** is a fabricated assembly of insulated conductors enclosed in flexible metal sheath. Also known as BX cable


Uses Permitted.

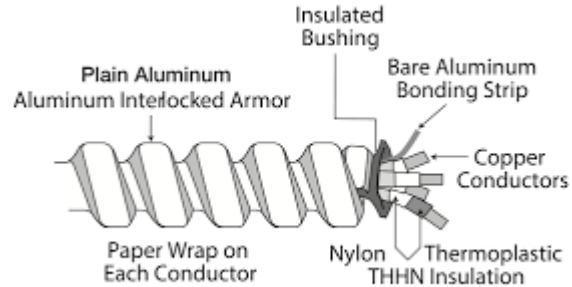
- (1) In both exposed and concealed work
- (2) In cable trays
- (3) In dry locations
- (4) Embedded in plaster finish on brick or other masonry, except in damp or wet locations
- (5) To be run or fished in the air voids of masonry block or tile walls where such walls are not exposed or subject to excessive moisture or dampness


Uses Not Permitted.


- (1) Where subject to physical damage
- (2) In damp or wet locations
- (3) In air voids of masonry block or tile walls where such walls are exposed or subject to excessive moisture or dampness
- (4) Where exposed to corrosive fumes or vapors
- (5) Embedded in plaster finish on brick or other masonry in damp or wet locations

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METAL CLAD CABLE (MC)


2. **Metal Clad Cable (MC)** is a factory assembled cable of one or more conductors each individual insulated and enclosed in a metallic sheath of interlocking tape of a smooth or corrugated tube. This type of cable is especially used for service feeders, branch circuit, and for indoor or outdoor work.




3.30.2.1 Uses Permitted.

(a) General Uses. Type MC cable shall be permitted as follows:

- (1) For services, feeders, and branch circuits
- (2) For power, lighting, control, and signal circuits
- (3) Indoors or outdoors
- (4) Exposed or concealed
- (5) To be direct buried where identified for such use
- (6) In cable tray where identified for such use
- (7) In any raceway
- (8) As aerial cable on a messenger
- (9) In hazardous (classified) locations as permitted
- (10) In dry locations and embedded in plaster finish on brick or other masonry except in damp or wet locations
- (11) In wet locations where any of the following conditions are met:
 - a. The metallic covering is impervious to moisture.

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b. A lead sheath or moisture-impervious jacket is provided under the metal covering.

c. The insulated conductors under the metallic covering are listed for use in wet locations.

(12) Where single-conductor cables are used, all phase conductors and, where used, the neutral conductor shall be grouped together to minimize induced voltage on the sheath.


3.30.2.3 Uses Not Permitted. Type MC cable shall not be used where exposed to the following destructive corrosive conditions, unless the metallic sheath is suitable for the conditions or is protected by material suitable for the conditions:


(1) Where subject to physical damage

(2) Direct burial

(3) In concrete

(4) Where subject to cinder fills, strong chlorides, caustic alkalis, or vapors of chlorine or of hydrochloric acids

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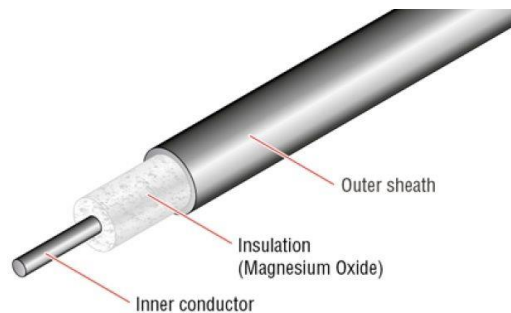
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MINERAL INSULATED (MI)


3. **Mineral Insulated Cable (MI)** is a factory assembly of one or more conductors insulated with a highly compressed refractory mineral insulation enclosed in a liquid and gas tight continuous copper sheath. This type of cable is used in dry, wet or continuous moist location as service feeders or branch circuit.

3.32.2.3 Uses Not Permitted. Type MI cable shall not be used under the following conditions or in the following locations:

- (1) In underground runs unless protected from physical damage, where necessary
- (2) Where exposed to conditions that are destructive and corrosive to the metallic sheath, unless additional protection is provided

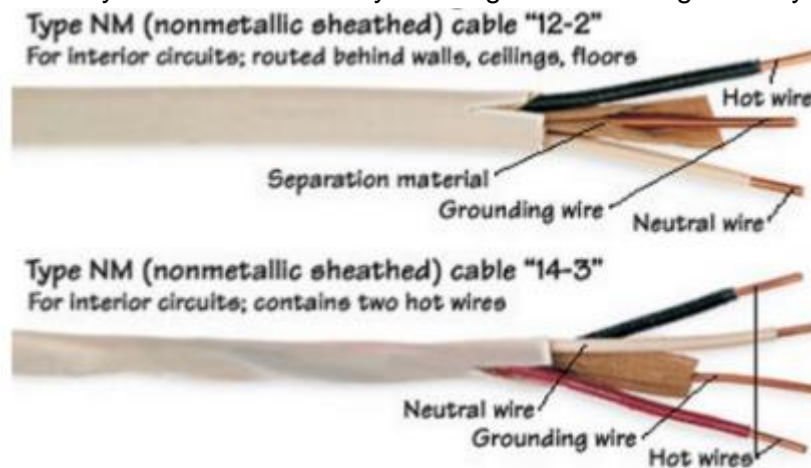


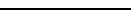
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NON-METALLIC SHEATHED CABLE (NM)

4. **Non-Metallic Sheathed Cable (NM)** is also a factory of two or more insulated conductors having a moisture resistant, flame retardant, and non-metallic material outer sheath. This type is used specifically for one or two family dwelling not exceeding 3 storey building.

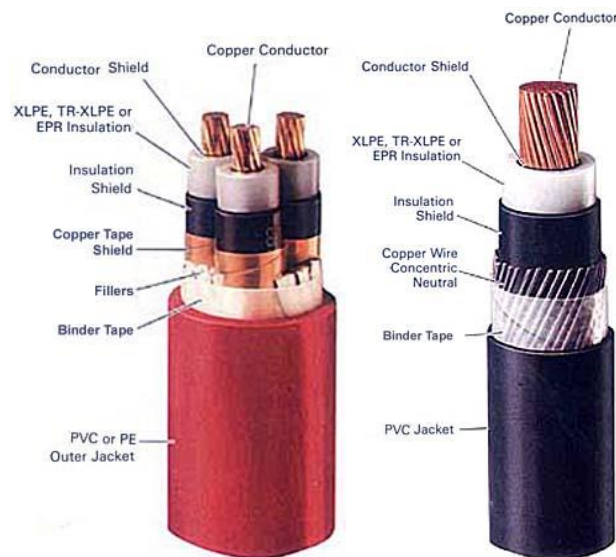



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SHIELDED NON-METALLIC CABLE (SNM)

5. **Shielded Non-Metallic Sheathed Cable (SNM)** this type of cable is a factory assembly of two or more insulated conductors in an extruded core of moisture resistant and flame retardant material covered within an overlapping spiral metal tape. This type is used in hazardous locations and in cable trays or in raceways.



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UNDERGROUND FEEDER AND BRANCH CIRCUIT CABLE (UF)

6. **Underground Feeder and Branch Circuit cable (UF)** is a moisture resistant cable used for underground connections including direct burial in the ground as feeder or branch circuit. A factory assembly of one or more insulated conductors with an integral or an overall covering of nonmetallic material suitable for direct burial in the earth.

3.40.2.1 Uses Permitted. Type UF cable shall be permitted as follows:

- (1) For use underground, including direct burial in the earth. For underground requirements, see 3.0.1.5.
- (2) As single-conductor cables. Where installed as single conductor cables, all conductors of the feeder grounded conductor or branch circuit, including the grounded conductor and equipment grounding conductor, if any, shall be installed in accordance with 3.0.1.3.
- (3) For wiring in wet, dry, or corrosive locations under the recognized wiring methods of this Code.
- (4) Installed as nonmetallic-sheathed cable. Where so installed, the installation and conductor requirements shall comply with Parts 3.34.2 and 3.34.3 and shall be of the multiconductor type.
- (5) For solar photovoltaic systems in accordance with 6.90.4.1.
- (6) As single-conductor cables as the non heating leads for heating cables as provided in 4.24.5.10.
- (7) Supported by cable trays. Type UF cable supported by cable trays shall be of the multiconductor type.

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SERVICE ENTRANCE CABLE

7. **Service Entrance Cable** - A single or multi-conductor assembly provided with or without an overall covering primarily used for service wire.

Type SE. Service-entrance cable having a flame-retardant, moisture-resistant covering.

Type USE. Service-entrance cable, identified for underground use, having a moisture-resistant covering, but not required to have a flame-retardant covering.

POWER AND CONTROL TRAY CABLE (TC)


8. **Power and Control Tray Cable (TC).** This is a factory assembled two or more insulated conductors with or without associated bare or covered grounding under a metallic sheath. This is used for installation in cable trays, raceways, or where it is supported by messenger wire.


3.36.2.1 Uses Permitted. Type TC cable shall be permitted to be used as follows:

- (1) For power, lighting, control, and signal circuits.
- (2) In cable trays.
- (3) In raceways.
- (4) In outdoor locations supported by a messenger wire.
- (5) For Class 1 circuits as permitted in Parts 7.25.2 and 7.25.3.
- (6) For non-power-limited fire alarm circuits if conductors comply with the requirements of 7.60.2.7.
- (7) In industrial establishments where the conditions of maintenance and supervision ensure that only licensed electrical practitioner or non licensed electrical practitioner under the supervision of a licensed electrical practitioner service the installation, and where the cable is continuously supported

3.36.2.3 Uses Not Permitted. Type TC tray cable shall not be installed or used as follows:

- (1) Installed where it will be exposed to physical damage
- (2) Installed outside a raceway or cable tray system, except as permitted in 3.36.2.1(7)
- (3) Used where exposed to direct rays of the sun, unless identified as sunlight resistant

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(4) Direct buried, unless identified for such use

3.40.2.3 Uses Not Permitted. Type UF cable shall not be used as follows:

- (1) As service-entrance cable
- (2) In commercial garages
- (3) In theaters and similar locations
- (4) In motion picture studios
- (5) In storage battery rooms
- (6) In hoistways or on elevators or escalators
- (7) In hazardous (classified) locations
- (8) Embedded in poured cement, concrete, or aggregate, except where embedded in plaster as nonheating leads where permitted in 4.24.5.10
- (9) Where exposed to direct rays of the sun, unless identified as sunlight resistant
- (10) Where subject to physical damage

FLAT CABLE ASSEMBLIES (FC)


9. **Flat Cable Assemblies (FC)** is an assembly of parallel conductors formed integrally with an insulating material web designed especially for field installation in wet; surface or raceways.


Installation

3.22.2.1 Uses Permitted. Flat cable assemblies shall be permitted only as follows:

- (1) As branch circuits to supply suitable tap devices for lighting, small appliances, or small power loads. The rating of the branch circuit shall not exceed 30 amperes.
- (2) Where installed for exposed work.
- (3) In locations where they will not be subjected to physical damage. Where a flat cable assembly is installed less than 2 400 mm above the floor or fixed working platform, it shall be protected by a cover identified for the use.
- (4) In surface metal raceways identified for the use. The channel portion of the surface metal raceway systems shall be installed as complete systems before the flat cable assemblies are pulled into the raceways.

3.22.2.3 Uses Not Permitted. Flat cable assemblies shall not be used as follows:

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- (1) Where subject to corrosive vapors unless suitable for the application
- (2) In hoistways or on elevators or escalators
- (3) In any hazardous (classified) location
- (4) Outdoors or in wet or damp locations unless identified for the use

FLAT CONDUCTOR CABLE (FCC)

10. **Flat Conductor Cable (FCC)** consists of three or more flat copper conductor placed edge to edge separated and enclosed within an insulating assembly. This type of cable is used for general purposes such as: appliance branch circuit, and for individual branch circuits, especially in hard smooth continuous floor surfaces and the like.

3.24.2.1 Uses Permitted.

(a) Branch Circuits.

(b) Branch-Circuit Ratings.

(2) Current. General-purpose and appliance branch circuits shall have ratings not exceeding 20 amperes. Individual branch circuits shall have ratings not exceeding 30 amperes.

(c) Floors.

(d) Walls.

(e) Damp Locations.

(f) Heated Floors.


Metal-Shield Connectors.


3.24.2.3 Uses Not Permitted. FCC systems shall not be used in the following locations:

- (1) Outdoors or in wet locations
- (2) Where subject to corrosive vapors
- (3) In any hazardous (classified) location


MEDIUM VOLTAGE CABLE (MV CABLE)


11. **Medium Voltage Cable (MV Cable)** is a single or multi-conductor solid dielectric insulated cable rated at 2,000 volts or higher. This type is used for power system up to 35,000 volts.

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LEARNING OUTCOME 3.2	Layout and install raceways
CONTENT: 1. Installation Guidelines of Raceways	
ASSESSMENT CRITERIA: 1. Discuss proper layout and installation of raceways 2. Follow guidelines in installing raceways	
CONDITION: Students/Trainees must be provided with the following: 1. WORKPLACE/LOCATION Computer, Laptop, Android Cellphone, MS Teams Account, Email Address 2. TOOLS, ACCESSORIES AND SUPPLIES White board Power Point presentation Marker 3. TRAINING MATERIALS Copy of the Module 1 Bond Paper Rubrics Criteria	
ASSESSMENT METHOD: Hands-on Activity Evaluation of Outputs (Portfolio) Written Test Demonstration Questioning Observation	

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Information Sheet 3.2.1

Installation Guidelines of Raceways

Learning Objectives:


After reading this INFORMATION SHEET, you should be able to:


1. Identify the application of raceways
2. Discuss installation guidelines in accordance with PEC

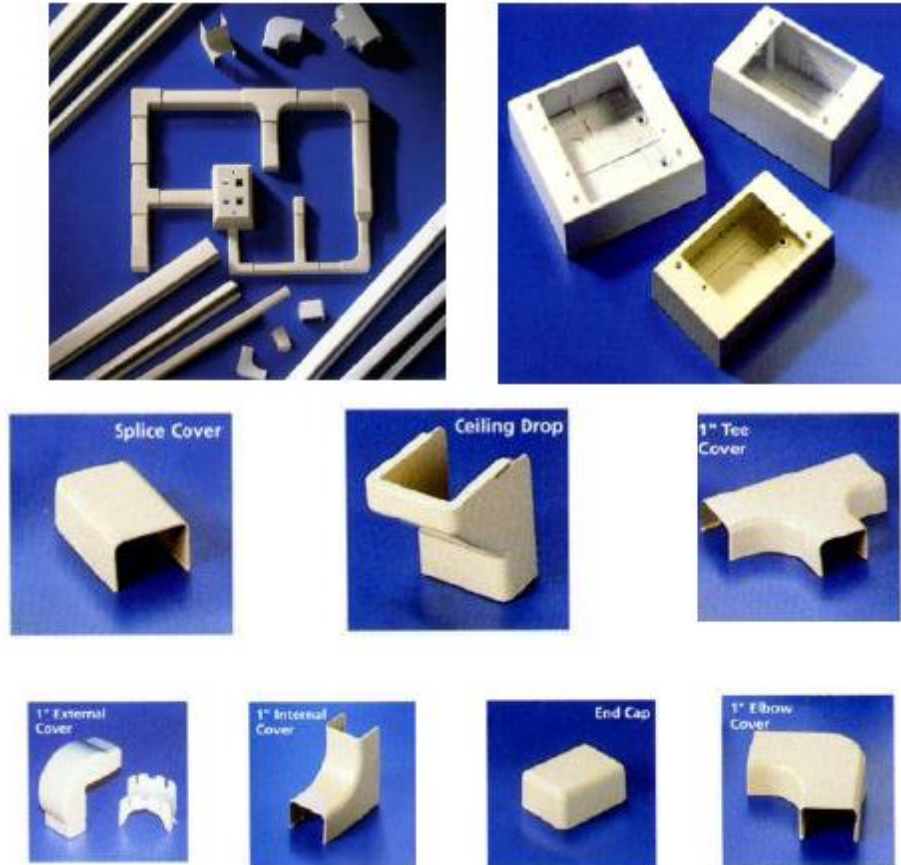
Raceway - An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this Code. Raceways include, but are not limited to, rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquid tight flexible conduit, flexible metallic tubing, flexible metal conduit, electrical nonmetallic tubing, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wire ways, and busways.

Surface Raceway is a one piece, non-metallic, adhesive backed latching raceway designed to aesthetically organize and route low voltage communications cables. It features a low profile design which blends into any environment whether it is new construction or a renovation. It is easy to cut and trim and is also printable with a latex based paint. It provides a complete line of fittings to manage connectivity requirements.

The fittings are available for each size raceway and color option. Single or Dual gang, junction boxes are versatile enough for any electrical application. Boxes are equipped with concentric knockouts for all 3 sizes of raceway. Knockouts are provided on all four sides. Junction boxes come with adhesive strips and #6 screws to secure the box to the base.

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Different Types of Surface Raceways


The National Electrical Code permits surface raceways in dry locations for exposed or surface work. The raceway can be extended through dry ways, dry partitions, and dry floors if one continuous length of raceway is used throughout the concealed section. The raceway cannot be used for concealed work on locations subject to severe to corrosive vapors, or in hoist ways and hazardous location.


Note: Please refer to the ebook Electrical Layout and Estimate Table 2-8 Characteristics of Raceways

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LEARNING OUTCOME 3.3	Identify correct quantity of Electrical conduits and fittings
CONTENT: <ol style="list-style-type: none"> 1. Metallic Conduits 2. Non-Metallic Conduits 	
ASSESSMENT CRITERIA: <ol style="list-style-type: none"> 1. Identify different type of Electrical conduit, its uses and installation guidelines in accordance with PEC 2. Choose the appropriate electrical conduits and fittings in an installation; 3. List quantity and electrical materials used in wiring installation base on electrical diagrams; and 4. Show awareness of the importance of observing safety in all electrical practices through an electrical diagram. 	
CONDITION: Students/Trainees must be provided with the following: <ol style="list-style-type: none"> 1. WORKPLACE/LOCATION Computer, Laptop, Android Cellphone, MS Teams Account, Email Address 2. TOOLS, ACCESSORIES AND SUPPLIES White board Power Point presentation 3. TRAINING MATERIALS Copy of the Module 1 Bond Paper Rubrics 	
ASSESSMENT METHOD: Hands-on Activity Evaluation of Outputs (Portfolio) Written Test Demonstration Questioning Observation	

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Information Sheet 3.3.1

Metallic Conduits

Learning Objectives:

After reading this INFORMATION SHEET, you should be able to:

1. Identify different types and applications of Metallic conduits and fittings;
2. Choose the appropriate electrical conduits and fittings in an installation;
3. List quantity and electrical materials used in wiring installation base on electrical diagrams; and
4. Show awareness of the importance of observing safety in all electrical practices through an electrical diagram.

Conduits


The term "electrical conduit" refers to durable tubing or other types of enclosure used to protect and provide a route for individual electrical wiring conductors. Conduit is typically required where wiring is exposed or where it might be subject to damage. A conduit can be made of metal or plastic and may be rigid or flexible. All conduit is installed with compatible fittings (couplings, elbows, connectors) and electrical boxes, usually made of the same or similar material. Conduit must be installed in accordance with the National Electrical Code (NEC) and all applicable local code rules.


Purpose of Electrical Conduits are:

1. To provide a means for the running wires from one point to another.
2. To physically protect the wires
3. To provide grounded enclosure
4. To protect the surroundings against the effect of fault in the wiring
5. To protect the wiring system from damage by the building and the occupants
6. To protect the building and the occupants from damage by the electric system

Conduit may be classified as:

1. Rigid Metal
2. Flexible Metal
3. Rigid Non-metal
4. Flexible Non-Metal

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	TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES Ayala Blvd., Ermita, Manila, 1000, Philippines Tel No. +632-301-3001 local 306 Fax No. +632-521-4063 Email: cie@tup.edu.ph Website: www.tup.edu.ph	Index No.	REF-CIE-INT-LRM
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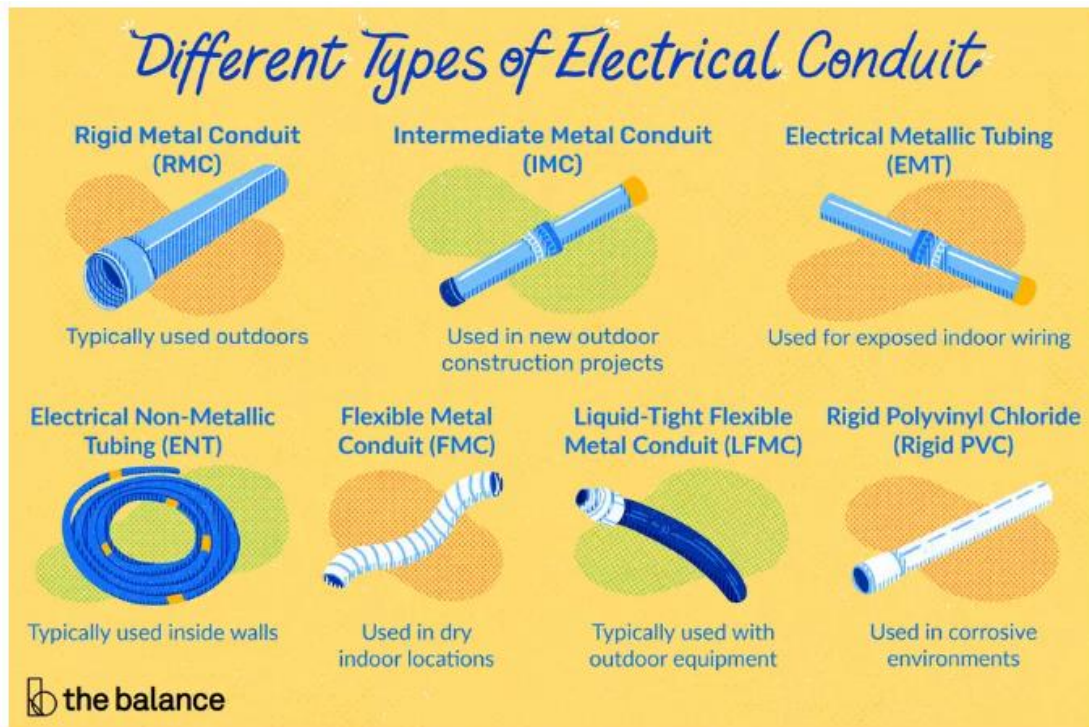



Image by Alison Czinkota © The Balance 2020


Metallic Conduits are those electrical raceways that are made of metal or similar materials such as steel and galvanized steel. Like non-metallic conduits, they consist of rigid type and flexible as well.

Rigid Metal Conduit—RMC and IMC

Rigid metal conduit, or RMC, is heavy-duty galvanized steel tubing that is installed with threaded fittings. It is typically used outdoors to provide protection from damage and can also provide structural support for electrical cables, panels, and other equipment. RMC is sold in 10- and 20-foot lengths and has threads on both ends.

Intermediate metal conduit, or IMC, is a thinner, lighter-weight version of rigid metal conduit and is approved for use in all of the same applications as RMC. Because IMC is lighter and easier to work with than RMC, it is more common in new construction.

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Service entrance installation



RMC with coupling

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Factory-bent elbows are available for all sizes of rigid conduit from ½ inch to 6 inches. However, bending small size RMC can be done using the *one-shot-bender* (Pic. 3), bigger sizes are done using a hydraulic bender.

For conduit turns and change in run direction, a conduit body called Condulets is more convenient to use than bending it at 90° since rigid metal conduits are tough to bend



Push

Pic. 3 – RMC bending

Rigid metal conduit is secured to junction boxes, utility boxes, panel boxes, and NEMA 3R by locknuts and end bushings. This locknut is turned on the threaded end of the conduit pipe with the teeth formed by the notches facing toward the box. The bushing on the end of the conduit thread secures the conduit to the inner wall of the outlet box and protects the wires from possible damage from the edge of the conduit.





Pic. 4 – LB Condulets

PEC 3.44.2.37 states that, conduit enters a box, fitting, “Where a or other enclosure be provided to protect the wire from abrasion unless the design of the box, fitting, or enclosure is such as to afford equivalent protection.”



Securing RMC to electrical box

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RMC shall be supported by using a metal C-clamp or saddle clamp with support distance as provided by PEC.




Conduit Size (inches)	Maximum Distance Between RMC Support (mm)
1/2" – 3/4"	3000
1"	3700
1 1/4" – 1 1/2"	4300
2" – 2 1/2"	4900
3" and larger	6100


Electrical Metallic Tubing—EMT

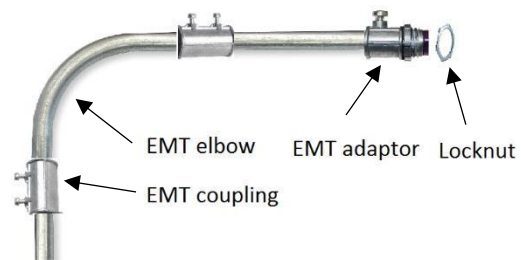
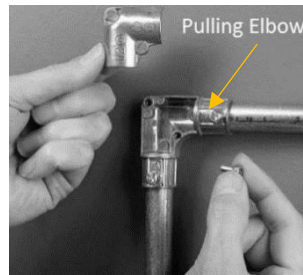
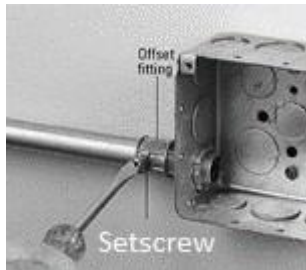
Another example of a rigid electrical conduit is EMT (electrical metal tubing), which is most commonly made of galvanized steel but can also be aluminum. EMT is also called "thin-wall" conduit because it is thin and lightweight, especially compared to RMC. Metallic tubing, therefore, does not offer the same protection against mechanical damage or the corrosive action of water or chemicals as does rigid metal conduit. EMT is rigid but can be bent with a simple tool called a conduit bender.

EMT is installed with couplings and fittings that are secured with setscrew or compression-type fasteners. The tubing itself is not threaded like RMC and IMC. Common sizes of EMT include 1/2-inch, 3/4-inch, and 1-inch. It is commonly used for exposed indoor wiring runs in residential and light commercial construction. If installed outdoors in exposed locations, it must be assembled with special watertight fittings.

Fittings used with this type of raceway are called EMT fittings. They are threadless fittings since the tube itself is not threaded and it should not be threaded according to PEC. The only means to secure the conduit run is through *setscrew or compression screws*.

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EMT fittings: adaptor, pulling elbow, and coupling


Metallic tubing may be used for open or concealed work where it will not be subject to severe mechanical damage or corrosive vapors. It is also used for exposed indoor installation.


Flexible Metal Conduit—FMC and LFMC

Flexible metal conduit (FMC) is also called "Greenfield," after the name of its inventor. It has a spiral construction that makes it flexible so it can snake through walls and other structures. Standard FMC is used in dry indoor locations, often for short runs between a wall box and a motor or fixed appliance, such as a garbage disposer.

Liquid-tight flexible metal conduit (LFMC) is a special type of flexible metal conduit that has a plastic coating and is used with sealed fittings to make it watertight. It is commonly used with outdoor equipment, such as air conditioner units.

This conduit is formed with a single strip of galvanized metal, wound in a spiral on itself, and interlocked to provide maximum strength with the greatest flexibility. Wires are to be pulled through this conduit. FMC may be used where a rigid raceway system requires a flexible section to meet difficult installation conditions. This wiring method is permitted to be used by PEC for branch circuits and not permitted as follows:

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Use of FMC


Uses Permitted	Uses NOT Permitted
• in dry location	• in hoistways
• concealed wiring	• storage battery room
• accessible locations	• underground direct earth burial
	• hazardous location where subject to physical damage
	• in lengths over 1800 mm.



*FMC / Metal Junction Box / Metal Utility Box / Metal Square Box /FMC
90° Connector /FMC Adaptor*


Electrical materials used in FMC wiring method


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FMC wiring method used in attics

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Information Sheet 3.3.2

Non-metallic Conduits

Learning Objectives:

After reading this INFORMATION SHEET, you should be able to:


1. Identify different types and applications of Non-metallic conduits and fittings;
2. Choose the appropriate electrical conduits and fittings in an installation;
3. List quantity and electrical materials used in wiring installation base on electrical diagrams; and
4. Show awareness of the importance of observing safety in all electrical practices through an electrical diagram.


Non-Metallic Conduits are electrical raceways that are made of plastic or similar materials. They resist corrosion and are lightweight and can be installed in wet and damp locations as the Code allows. The most common non-metallic conduits that are used in house wiring installation are the PVC (polyvinyl chloride conduit) and the CPC (corrugated plastic conduit), also known as ENT (electrical non-metallic tubing).

Rigid PVC Conduit PCV

Commonly used in a corrosive environment such as wet and damp location and is best installed in concealed wiring applications.

Rigid polyvinyl chloride (PVC) is similar to plastic plumbing pipe and is installed with plastic fittings that are glued in place. It can be bent after being heated in a portable heater box. Because the conduit tubing and fittings are glued together, the conduit assemblies can be watertight, making PVC suitable for direct burial in the ground for many applications. It is also allowed in corrosive environments.

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Rigid Non-Metallic Conduit (PVC)


Non-metallic conduits are electrical materials which are manufactured to be resistant to moisture and chemical atmosphere. They are also manufactured to be flame retardant or not easily burned. They are resistant to impact and crushing. They do not easily get out shape by the heat. These conduits are classified according to the materials they are made of. The most common ones are asbestos cement conduit, polyvinyl chloride, conduit and high density polyethylene conduit.


The Philippine Electrical Code provides that rigid non-metallic conduit may be used under the following conditions:

1. Concealed in floors, walls and ceilings
2. Direct earth burial or underground
 - ☐ 300 mm in trench below 50mm thick concrete or equivalent
 - ☐ 600 mm under streets, highways, roads, alleys, driveway and parking lots
 - ☐ 460 mm under driveways and parking lots of single and two family dwelling units
 - ☐ 460 mm under airport runways, including adjacent areas where trespassing is prohibited
3. In locations subject to severe corrosive influences
4. In locations where subject chemicals for which the materials are specifically approved
5. Cinder fill
6. In wet locations, laundries, canneries, or other wet locations and in locations where walls are frequently washed provided water is prevented from entering the conduit
7. In dry and damp locations

The Philippine Electrical Code prohibits the use of rigid non-metallic conduit under the following conditions:

1. Hazardous (Classified) locations
2. Support of fixtures
3. Physically damaged location
4. Ambient temperature. Where subject to ambient temperatures in excess of 50oC unless listed otherwise

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5. Insulation temperature limitations. For conductors whose insulation temperature limitations would exceed those for which the conduit is listed.
6. Theaters and similar locations.

INSTALLATION OF NON-METALLIC CONDUIT PEC REQUIREMENTS

1. **TRIMMING.** Rough edges or burrs at the cut ends of non-metallic conduit shall be trimmed inside and outside



2. **JOINTS.** Joints between lengths of conduit and between conduit couplings, fittings and, boxes shall be made with approved coupling and adapter. For water proofing, PVC cement should be spread around the surfaces to be joined together

3. **SECURING and SUPPORTS.** Rigid non-metallic conduit shall be rigidly supported as indicated below


- RNC shall be supported (by PVC support clamp) with space interval not exceeding the Code requirement


Conduit Size (inches)	Maximum Spacing Between Support (mm)
3/8" – 1"	900
1 1/4" – 2"	1500
2 1/2" – 3"	1800
3 1/2" – 5"	2100
6"	2400

Support for Rigid Nonmetallic Conduit

4. **EXPANSION FITTINGS.** Expansion fitting for rigid nonmetallic conduit shall be provided to compensate for thermal expansion and contraction.

5. **MINIMUM SIZE.** Rigid nonmetallic conduit smaller than 15 mm (20 mm) electrical trade size shall not be used.

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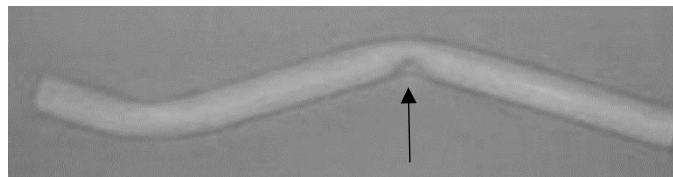
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6. **MAXIMUM.** Rigid nonmetallic conduit larger than 150 mm (160 mm) electrical trade size shall not be used.

7. **BUSHING.** Where conduit enters a box, fitting or other enclosure, a bushing or adapter shall be provided to protect wires from abrasion unless the box, fitting or enclosure design provides equivalent protection.

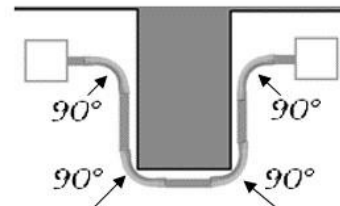
8. **BENDS-HOW MADE.** Bends of rigid nonmetallic conduit shall be so made that the conduit will not be damaged and that the internal diameter of the conduit will not be effectively reduced.

- bends shall be so made that the conduit will not be damaged and the internal diameter of the conduit will not be effectively reduced



no kinks


- There shall **not** be more than the equivalent of four quarter bends or 360 degrees total (*Pic. 2*)




Maximum bend per complete run (box to box)

- Radius of 90° conduit bending should be 10 cm



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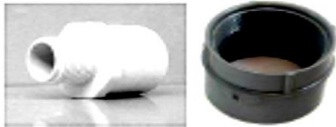
Types of PVC Fittings



PVC Coupling



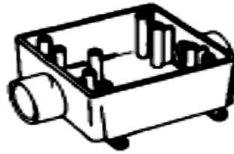
PVC elbow



Adapter



PVC Conduit Pipe



PVC 2G box



LL Access Fitting



1 Inch Type T Condulet




1/2 Inch Type T PVC Condulet




3/4 inch Type LL PVC Access Fitting



PVC Conduit Clamps

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Electrical Non-Metallic Tubing—ENT

Electrical nonmetallic tubing (ENT) is a thinned wall corrugated conduit that is flame retardant and moisture resistant. This conduit is also called as corrugated plastic conduit (CPC) and popularly known as the flexible hose. Typically used in attics and inside walls (for concealed wiring). It is easy to install due to its flexible characteristic and can easily bend by hand. It is easy to bend and installs with snap-lock or glued plastic fittings. In addition to installation in standard wood- or metal-frame walls, ENT can be installed inside concrete block structures and can be covered with concrete. Due to the blue color of one common brand of this conduit, ENT is nicknamed "smurf tube," after the Smurfs cartoon characters.



CPC



plastic junction and utility box





CPC adaptor

Flexible Nonmetallic Conduit

This portion of information sheet is lifted from Philippine Electrical Code, 2000, Part I.
Definition. Liquid tight flexible nonmetallic conduit is a listed raceway of circular cross section of various types as follows:

1. A smooth seamless inner core and cover bonded together and having one or more reinforcement layers between the core and cover designated as Type LFNC-A.
2. A smooth inner surface with integral reinforcement within the conduit wall, designated as Type LFNC-B.
3. A corrugated internal and external surface without integral reinforcement within the conduit wall, designated as Type LFNC-C.

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This conduit is flame resistant and, with fittings, is approved for the installation of electrical conductors.

Uses.

(a) **Permitted.** Listed liquid tight flexible nonmetallic conduit shall be permitted to be used in exposed or concealed locations for the following purposes. FPN: Extreme cold may cause some types of nonmetallic conduits to become brittle and therefore more susceptible to damage from physical contact.


- (1) Where flexibility is required for installation, operation, or maintenance.
- (2) Where protection of the contained conductors is required from vapors, liquids, or solids.
- (3) For outdoor locations where listed and marked as suitable for the purpose. FPN: For marking requirements, see Section 110.1.21
- (4) For direct burial where listed and marked for the purpose.
- (5) Liquid tight flexible nonmetallic conduit as defined in Section 3.51.2.1(2) shall be permitted to be installed in lengths longer than 1 800 mm where secured in accordance with Section 3.51.2.6. 43


(b) **Not Permitted.** Liquid tight flexible nonmetallic conduit shall not be used in the following:

- (1) Where subject to physical damage
- (2) Where any combination of ambient and conductor temperature is in excess of that for which the liquid tight flexible nonmetallic conduit is approved
- (3) In lengths longer than 1 800 mm, except as permitted by Section 3.51.2.2(a)(5) or where a longer length is approved as essential for a required degree of flexibility.
- (4) Where voltage of the contained conductors is in excess of 600 volts, nominal Exception. As permitted in Section 6.0.2.3(a) for electric signs over 600 volts.

Size. The electrical trade sizes of liquid tight flexible nonmetallic conduit shall be in accordance with (a) or (b):

- (a) 15mm (20 mm) to 100mm (110mm) inclusive
- (b) 10 mm (15 mm) as permitted below
- (1) For enclosing the leads of motors as permitted in Section 4.30.13.5(b) (2) In lengths not exceeding 1 800 mm as part of a listed assembly for tap connections

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to lighting fixtures as required in Section 4.10.13.4(c), or for utilization equipment (3) for electric sign conductors in accordance with Section 6.0 .2 .3 (a)

Number of Conductors. The number of conductors permitted in a single conduit shall be in accordance with the percentage fill specified.

Fittings. Liquid tight flexible non - metallic conduit shall be used only with listed terminal fittings. Angle connectors shall not be used for concealed raceway installations.

Securing and Supporting. Liquid tight flexible nonmetallic conduit, as defined in Section 3.51.2.1(2), shall be securely fastened and supported in accordance with one of the following. 44

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(a) The conduit shall be securely fastened at intervals not exceeding 900 mm and within 300 mm on each side of every outlet box, junction box, cabinet, or fitting.

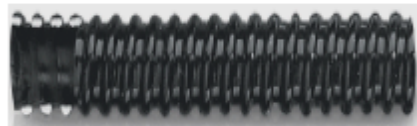
(b) Securing and supporting of the conduit shall not be required where it is fished, installed in lengths not exceeding 900 mm at terminals where flexibility is required, or where installed in lengths not exceeding 1 800 mm from a fixture terminal connection for tap conductors to lighting fixtures as permitted in Section 4.10.13.4(c)

(c) Horizontal runs of liquid tight flexible nonmetallic conduit supported by openings through framing members at intervals not exceeding 900 mm and securely fastened within 300 mm of termination points shall be permitted.

Flexible Nonmetallic Conduit Fittings




Coupling




Flexible Nonmetallic Conduit



Adapter

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Liquid tight angle connector

Liquid tight straight connector


TABLE 2-9 MAXIMUM NUMBER OF WIRES IN A CONDUIT


Size of Wire	Number of Wires in One Conduit (mm)								
	1	2	3	4	5	6	7	8	9
14	13	13	13	20	20	25	26	27	28
12	13	13	20	20	20	25	25	25	32
10	13	20	20	25	25	25	32	32	32
8	13	20	25	25	25	32	32	32	32
6	13	25	32	32	38	38	50	50	50
5	20	32	32	32	38	50	50	50	50
4	20	32	32	38	50	50	50	50	63
3	20	32	32	38	50	50	60	63	63
2	20	32	38	38	50	50	63	63	63
1	20	38	38	50	50	63	63	75	75

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LEARNING OUTCOME 3.4	Identifying Correct Quantity of Electrical Boxes and Fittings
CONTENT: <ol style="list-style-type: none"> 1. Panel Box/Fuse Box 2. Utility Box 3. Junction Box 4. Connectors / Adaptors 	
ASSESSMENT CRITERIA: <ol style="list-style-type: none"> 1. Identify different types and applications of electrical boxes and fittings; 2. Choose the appropriate electrical box and fittings in an installation; 3. List the exact quantity of electrical materials used in wiring installation through electrical diagrams; and 4. Value the importance of observing safety in all electrical practices through an electrical diagram. 	
CONDITION: <p>Students/Trainees must be provided with the following:</p> <ol style="list-style-type: none"> 1. WORKPLACE/LOCATION Computer, Laptop, Android Cellphone, MS Teams Account, Email Address 2. TOOLS, ACCESSORIES AND SUPPLIES White board Power Point presentation Marker 3. TRAINING MATERIALS Copy of the Module 1 Bond Paper Rubrics Criteria 	
ASSESSMENT METHOD:	

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Hands-on Activity Evaluation of Outputs (Portfolio) Written Test Demonstration Questioning Observation

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Information Sheet 3.4.1

Panel Box/Fuse Box

Learning Objectives:

After reading this INFORMATION SHEET, you should be able to:

1. Choose the appropriate Panel/Fuse box and fittings in an installation;
2. Identify different types of Panel/Fuse box
3. List the exact quantity of electrical materials used in wiring installation through electrical diagrams; and
4. Value the importance of observing safety in all electrical practices through an electrical diagram.

A **Panel Box**, also known as a service panel or breaker box, is a box, usually made of metal that holds or secures circuit breakers that are connected to house circuits that supply electrical power.



PB Single2



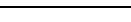
Pole Circuit Breaker




PB 2x2



PB 3x3

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PB 4x4



PB 5x5


Types of Panel Box with Circuit Breaker


Panel Box Variation	No. of Holes	No. of Branch	Main Disconnecting	Spare
2x2	4	2	1	1
3x3	6	4	1	1
4x4	8	6	1	1
5x5	10	8	1	1
6x6	12	10	1	1
7x7	14	12	1	1
8x8	16	14	1	1
9x9	18	16	1	1
10x10	20	18	1	1

Table 1 – Panel Box Variation
NEMA 3R Metal Enclosure (National Electrical Manufacturers Association) Similar to the panel box, this electrical box is used to house the main circuit breaker that protects the entire house circuit which is usually installed outdoor.



NEMA 3R

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Miniature CB Panel Box is a widely used panel box today for house wiring installation. Though like an ordinary circuit breaker and its panel box as to its application and purpose, the mini CB panel box with its mini circuit breaker is more compact, space-saving, and easier to use.





*Miniature Circuit Breaker Panel
Box with 2 Pole Mini Circuit breaker*

Though this is no longer very much in use and more or less obsolete in this modern time, *Fuse Box* with its fuse in it still serves its purpose in protecting the entire house circuit from the risk of an electrical fire.



Fuse Box with Cartridge Fuse

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Information Sheet 3.4.2

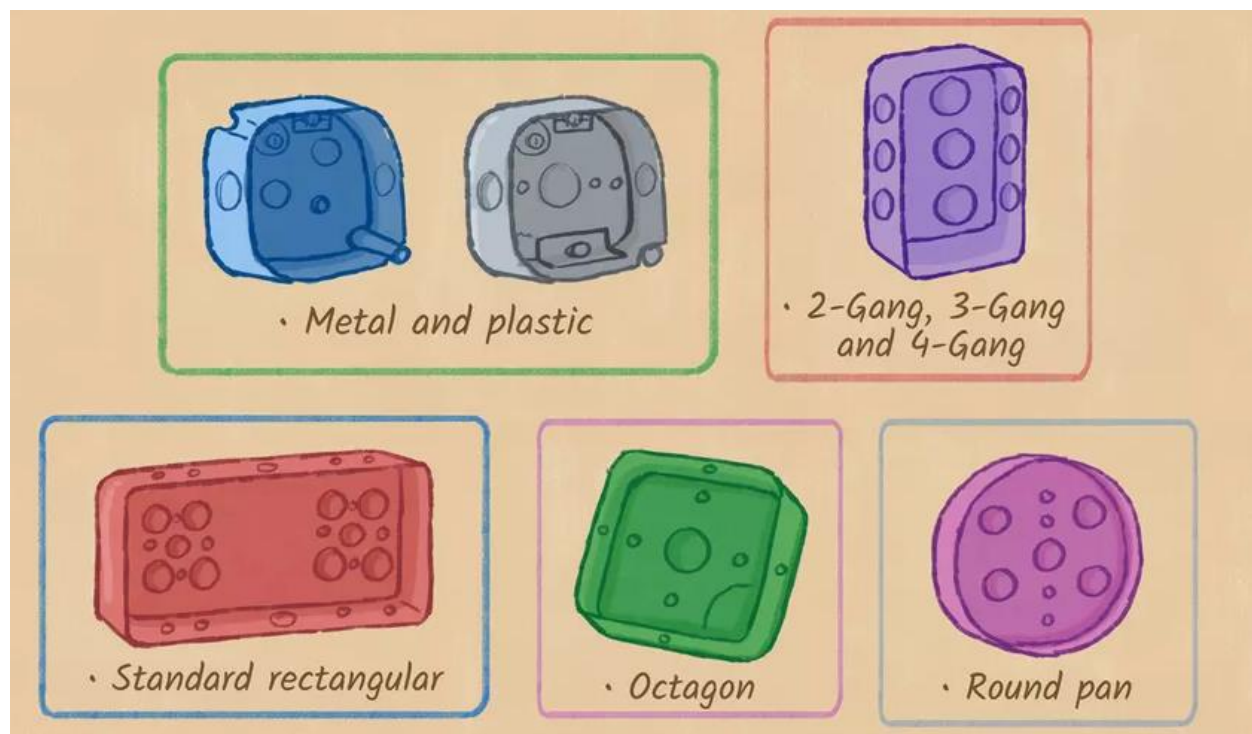
Utility and Junction Box


Learning Objectives:


After reading this INFORMATION SHEET, you should be able to:

1. Choose the appropriate Utility box, Junction box and fittings in an installation;
2. Identify different types of Utility box and Junction box
3. List the exact quantity of electrical materials used in wiring installation through electrical diagrams; and
4. Value the importance of observing safety in all electrical practices through an electrical diagram.

PEC PROVISION IN INSTALLING ELECTRICAL BOXES



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Electrical codes require that all wire connections or cable splices be inside an approved metal or plastic box. And every box must be accessible – you cannot bury inside a wall. This protects your home from the danger of fire and make it easier to inspect and upgrade your wiring in the future.

Codes govern how many connections you are allowed to make within a box, depending on its size. If you must make more connections, you have to use a larger box.


Boxes for switches and receptacles serve as workhorses in any electrical installation. Some of the metal ones can be ganged in to double, triple, or larger multiples by removing one side and linking them together.


Boxes should be installed so that the outside edges are flushed with the finishing material. Presumably, you know what materials you will be using, but make sure that you know the thickness of any paneling, wallboard, or combinations. (For 3/8-inch drywall plus ¼-inch paneling, for example the box should stick out 5/8-inch from the front of the framing.) The code allows boxes to be as deep as ½ inch behind the surface of noncombustible materials, such as gypsum wallboard, brick, or concrete block. This may cause a problem; however lining up the receptacle and cover plate, so have the outside edges flush with the finishing material in all cases.

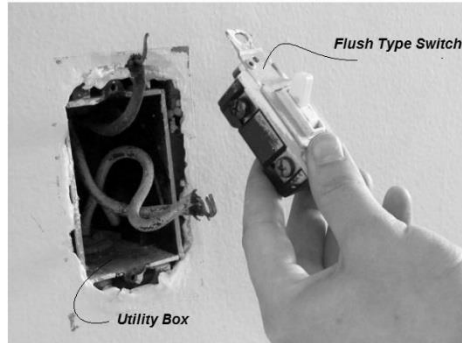
A **Utility Box** is an electrical box commonly used in a concealed wiring method where electrical materials such as a wire in conduits, switches, and outlets are imbedded or flushed to the wall. The purpose of this box is to house flush type switches and outlets. The utility box comes in two types: the metal utility box, and the PVC (plastic) utility box.



PVC Utility Box Metal Utility Box
Utility Box

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Application of Utility Box





Flush type Switch in a Utility Box, Concealed Wiring

Pictures shows exactly how utility boxes are used in an electrical installation using the concealed wiring method. Application for the flush type is very much like a flush type convenience outlet.

Weatherproof Box

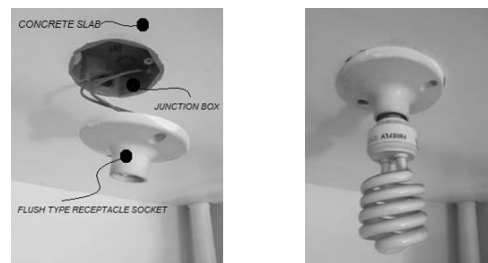
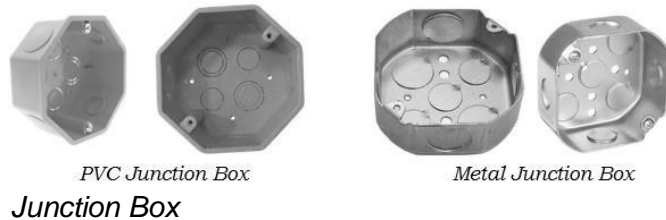
- Also known as an outdoor box.
- Used for exterior switches or receptacles.
- Thicker than interior boxes and has a rubber gasket between the cover and the box to keep out water.
- Covers are screw-on or snap-on.

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A **Junction Box** is an octagonal shaped electrical box usually used as part of a concealed wiring method. Like the utility box, the junction box comes in two types: the metal junction box and the plastic or PVC junction box.



Junction Box on Concrete Slab

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Picture shows one application of junction box in wiring installation. If you are planning to install a flush type receptacle socket on a concrete slab ceiling for lighting purposes, this will be possible by embedding a junction box with its raceway in a concrete slab. This is done during the construction of the concrete slab. Once it is done, you can now secure a flush type socket on the concrete slab ceiling.

Another application of junction box in wiring installation is mentioned in PEC under Article 3.90.1.6. Splices and Taps that say: *Splices and taps shall be made only in junction boxes.* The only location allowed by PEC to do the splices and joints or taps especially in the concealed wiring method is the junction box.



Junction Box as Location for Splices and Joints

Other PEC provisions in the use of electrical boxes:

- 1.10.1.12 (a) – Unused openings shall be effectively closed to afford protection
- 3.14.2.14 (c) – All junction boxes and conduit bodies shall be provided with covers compatible with the box
- 3.0.1.14 – At least 150 mm of free conductor, measured from the point in the box where it emerges



1.10.1.12 (a)





3.14.2.14 (c)



3.0.1.14

PEC Provisions on the

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Use of Junction Box

Another type of junction box is the **Square Box** which is bigger. This electrical box provides more space for splices and joints and taps.



Metal Square Box Plastic or PVC Square Box
Square Box

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Information Sheet 3.4.2

Conduit Fittings

Learning Objectives:

After reading this INFORMATION SHEET, you should be able to:


1. Choose the appropriate Conduit fittings in an installation;
2. Identify different types of Conduit fittings
3. List the exact quantity of electrical materials used in wiring installation through electrical diagrams; and
4. Value the importance of observing safety in all electrical practices through an electrical diagram.


Conduit Fittings (also called electrical fittings) are small electrical materials commonly used to connect conduit runs to electrical boxes. Electrical fittings include couplings, connectors or adaptors, and elbows.

Connectors also called adaptors are used to connect conduits to an electrical box. The kind of connector to be used in electrical installation will depend on the kind of conduit used.



Connectors or Adaptors with Lock Nut

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EMT



CPC



*FMC
Couplings*

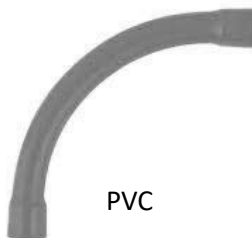


PVC



RSC

Conduit Elbows are used to connect two rigid conduits in a 90-degree turn as to a corner of a wall.



PVC





EMT



RSC

Electrical Elbow

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Conduit Body or Condulets are defined as a separate portion of a conduit or tubing system that provides easy access through a removable cover to the interior of the raceway system. Conduit bodies can be used as a junction and are also used as pull boxes and installed in a raceway system to facilitate a change in direction.




to facilitate a change in
Conduit Body or Condulets

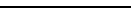



Pic. 6 – LLeft and LRight Condulets

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LEARNING OUTCOME 3.5	Interpreting Diagrams with Outlets
CONTENT: <ol style="list-style-type: none"> 1. Convenience Outlet 2. Special Purpose Outlet (SPO/ACU) 3. Ground Fault Circuit Interrupter (GFCI) 	
ASSESSMENT CRITERIA: <ol style="list-style-type: none"> 1. Identify different types of outlets; 2. Differentiate the application of outlets; 3. Determine how each type of outlets are used; 4. Analyze proper procedure in installing gfci; 5. Draw electrical diagram with types of outlets; 6. Perform basic interpretation of electrical diagram with power outlets; and 7. Observe the importance of safety in all electrical practices through electrical diagram. 	
CONDITION: <p>Students/Trainees must be provided with the following:</p> <ol style="list-style-type: none"> 1. WORKPLACE/LOCATION Computer, Laptop, Android Cellphone, MS Teams Account, Email Address 2.TOOLS, ACCESSORIES AND SUPPLIES White board Power Point presentation Marker 3.TRAINING MATERILAS Copy of the Module 1 Bond Paper Rubrics Criteria 	
ASSESSMENT METHOD: Hands-on Activity Evaluation of Outputs (Portfolio)	

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Written Test Demonstration Questioning Observation

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Information Sheet 3.5.1

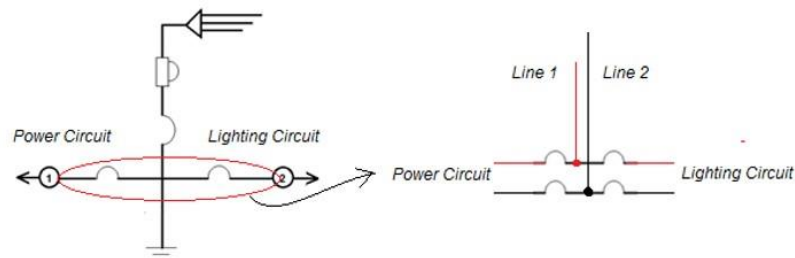
Convenience and Special Purpose Outlet

Learning Objectives:

After reading this INFORMATION SHEET, you should be able to:


1. Identify different types of outlets;
2. Differentiate the application of outlets;
3. Determine how each type of outlets are used;
4. Draw electrical diagram with types of outlets;
5. Perform basic interpretation of electrical diagram with power outlets; and
6. Observe the importance of safety in all electrical practices through electrical diagram.


House wiring installation consists of several branch circuits. Each branch circuit is independent from each other. This means when one branch circuit is turned OFF, in trouble, or under maintenance, the remaining branch circuit will not be affected. As shown in *Pic. 1*, two branch circuits are installed: 1 for the lighting circuit, and another 1 for the power circuit.



Riser Diagram with 2 Branch Circuits

Power circuit is a house circuit intended for our small appliances and portable devices that require a power source. These are the convenience outlets in our home where all electrically operated devices are plugged in.

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Outlet. A point on the wiring system at which current is taken to supply utilization equipment. In a simple term, an outlet is any point that supplies an electric load. An outlet usually consists of a small metal or non-metal box into which a raceway and or cable ends:

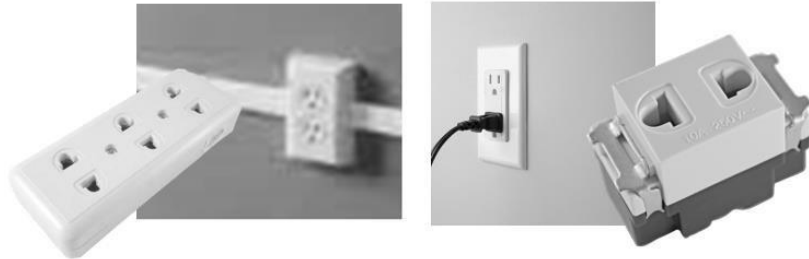
Different kinds of outlet

1. Convenience outlet or attachment cap.
2. Lighting outlet.
3. Receptacles outlet

A Convenience outlet or attachment cap is a device that by insertion into a receptacle establishes connection between the conductor of the. flexible cord and the conductors connected permanently to the receptacle.


Classification of Convenience Outlets


Just like our switches, convenience outlets are classified into two: the surface type and the flush type convenience outlet.



Surface Type and Flush Type Outlets

Whether it be a surface type or a flush type, both provide the same purpose: to supply electric power to our appliances, gadgets, and devices. Imagine a house without power outlets. That is where the name comes from, this electrical material provides us convenience by way of easy access to a power source for our home appliance.

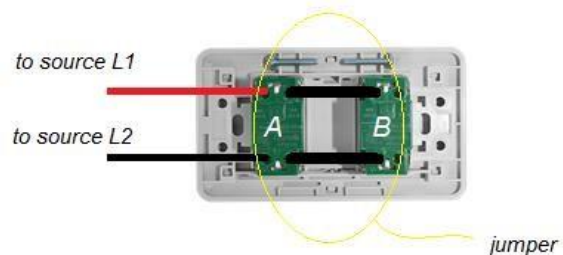
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Convenience Outlet Connection

Duplex convenience outlets are the usual power outlets we install in our home.

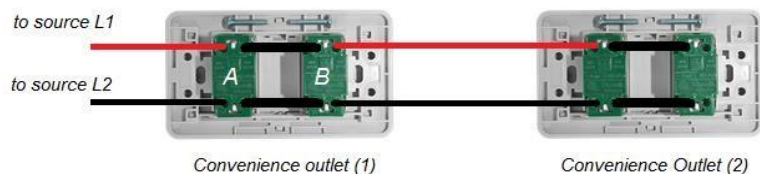
Installation of this electrical material is easy but must follow PEC provisions to keep installation safe.



Line 1 / 2 Connection

A jumper must be connected from outlet A to B to energize outlet B. Line 1 and 2 on opposite sides can be connected inter-changeably without affecting the circuit connection. NEVER connect both lines on the same side. It will result in a short circuit.

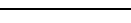
You can do this same procedure if you want to add a duplex convenience outlet in your circuit as shown in *Picture..*




Two Convenience Outlet Connection

Common Practices in the Installations of Convenience Outlet

- minimum size of wire allowed – 3.5 mm² (12 AWG)
- maximum distance between outlets – 3 600 mm
- distance from the floor – 300 mm

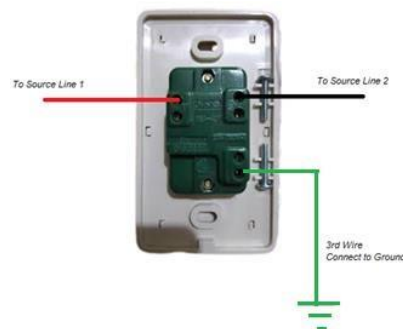
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A special-purpose outlet is a three slotted outlet intended for a bigger appliance load with a three-pronged plug. The air conditioning unit (ACU) is a good example of this home appliance that requires this kind of power outlet. Bigger appliance such as the air conditioning unit requires more current to operate. Because of this, a third wire is necessary for extra safety. The 2 wires of the convenience outlet are intended for Line 1 and 2, the third wire of the ACU outlet, on the other hand, is intended for the ground. The idea of grounding for this type of power outlet is to protect the people from electric shock by connecting the metal casing to the ground.



ACU Outlet Connection





Pic. 1 – ACU Outlet Connection

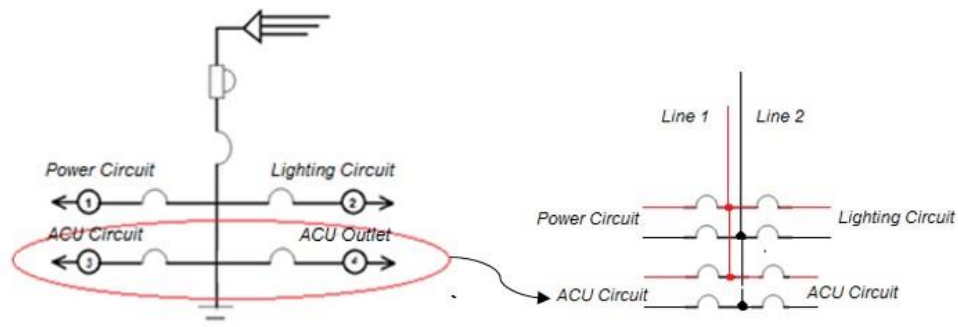
You may ask, “what will happen if the ground line is disregarded in the installation?”. Nothing really, the appliance will still operate normally. What was done, however, is disabling an important safety feature that will protect a person from possible electric shock if a wire comes loose.

Safety Practices in installing ACU outlets


- size of wire used is 10 AWG (5.5mm²)
- size for the ground wire is two sizes smaller (14 AWG/2.0 mm²)
- 1 branch circuit for each ACU outlet (i.e. if you have 2 ACUs, you must provide 2 branch circuits for this installation as shown in *Pic. 2*)


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Pic. 2 – Riser Diagram with 2 ACU Branch Circuits

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Information Sheet 3.5.2

Ground Fault Circuit Interrupter Outlet

Learning Objectives:

After reading this INFORMATION SHEET, you should be able to:

1. Analyze proper procedure in installing gfci;
2. Draw electrical diagram with types of outlets;
3. Perform basic interpretation of electrical diagram with power outlets; and
4. Observe the importance of safety in all electrical practices through electrical diagram.

The PEC defines ground fault circuit interrupter or GFCI as a device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a device.


If the circuit breaker protects the entire house circuit from electrical trouble that might result in an electrical fire, GFCI on the other hand protects a person from electrocution that might lead to death. It is another type of convenience outlet that can prevent electric shock.


GFCI are generally installed where electrical circuits may accidentally come in contact with water such as:

- laundry area
- kitchen countertop
- bathroom lavatory/water heater
- dirty kitchen, etc.



Front and Back of GFCI

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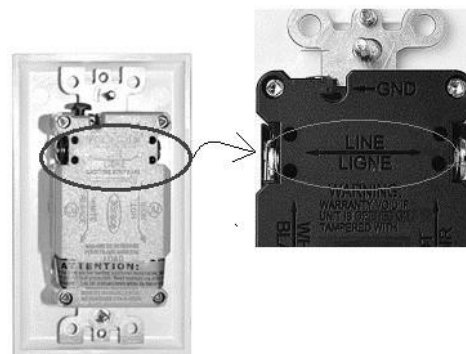
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GFCI Connection

Unlike an ordinary convenience outlet, GFCI requires 3 wires: Line 1, Line 2, and the ground wire. If the ground wire will not be connected to the GFCI, this will not affect its operation, it will still supply electricity to the appliance plugged into it. But it will not serve its purpose, to protect a person from being electrocuted. This GFCI (without ground wire) will be just an ordinary, too expensive, convenience outlet.

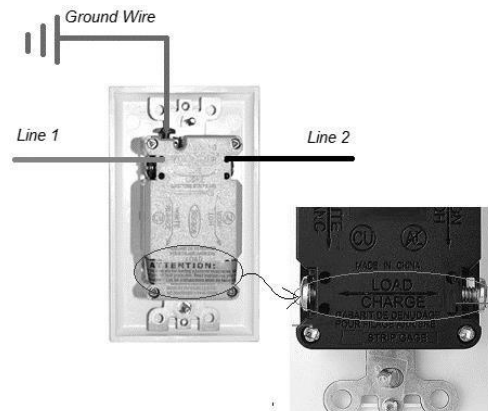
Procedure in installing GFCI:

1. Check the back of GFCI and look for the "LINE" side.





Line Terminal of GFCI

2. Connect the power line (Line1 and 2) to the LINE side terminal of GFCI and **NOT** on the opposite which is the LOAD side.

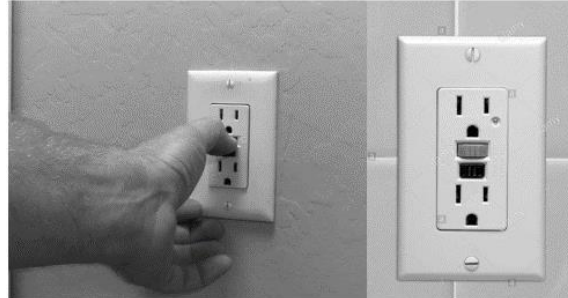


GFCI Connection

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3. Connect the ground wire to green screw
4. Double-check termination of wire
5. With power ON, test GFCI by pressing the “test button” (black), the light indicator should turn off. Then press the “reset button” (red) to energize it. The light indicator should turn on.

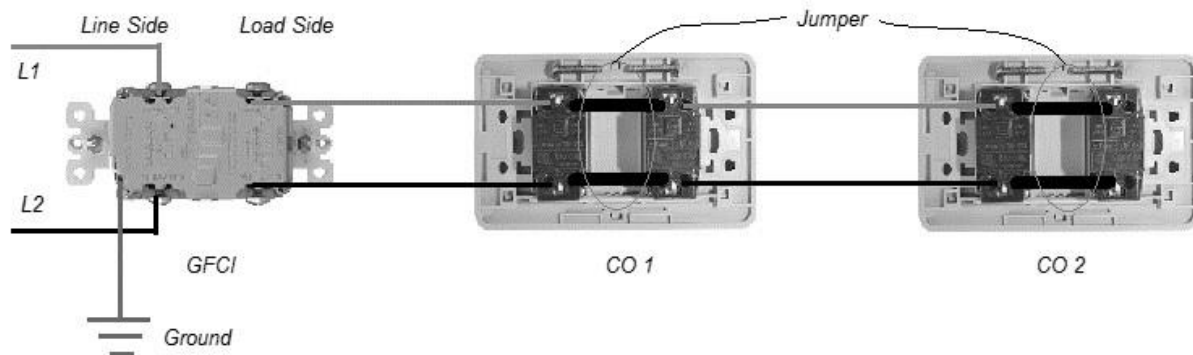


Test GFCI


How Does GFCI Works?


Normally, the determined amount of electric current passes from Line 1 to load then back to Line 2. When GFCI “sense” the difference (or there was a “spill”) in the amount of electricity flowing into the circuit to that flowing out, even in the smallest amount of current, as small as 4 or 5 milliamps, the GFCI will react quickly (less than one-tenth of a second) to trip or shut off the circuit and prevent a possible electric shock.

An additional convenience outlet can be installed in the circuit with the GFCI. This will maximize the use of GFCI by adding additional protection to other convenience outlets installed with it as shown in *Pic. 5*. Just connect the additional outlets on the LOAD side of the GFCI to provide the same protection as the GFCI provides.





*GFCI with Ordinary Convenience Outlet *

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LEARNING OUTCOME 3.6	Classify switches based on their uses and function
CONTENT: 1. Different types of Switches Circuit connections of special switches	
ASSESSMENT CRITERIA: 1. Identify different types of switches; 2. Differentiate application of switches; 3. Determine how each type of switches is used; 4. Draw schematic diagrams using types of switches; 5. Perform basic interpretations of electrical diagram; and 6. Show awareness of the importance of observing safety in all electrical practices through electrical diagram.	
CONDITION: Students/Trainees must be provided with the following: 1. WORKPLACE/LOCATION Computer, Laptop, Android Cellphone, MS Teams Account, Email Address 2.TOOLS, ACCESSORIES AND SUPPLIES White board Power Point presentation Marker 3.TRAINING MATERILAS Copy of the Module 1 Bond Paper Rubrics Criteria	
ASSESSMENT METHOD: Hands-on Activity Evaluation of Outputs (Portfolio)	

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Written Test Demonstration Questioning Observation

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Information Sheet 3.6.1

Classify switches based on their uses and function

Learning Objectives:

After reading this INFORMATION SHEET, you should be able to:

1. Classify switches based on their uses and function
2. Identify different types of switches;
3. Differentiate application of switches;
4. Determine how each type of switches is used;
5. Draw schematic diagrams using types of switches;
6. Perform basic interpretations of electrical diagram; and
7. Show awareness of the importance of observing safety in all electrical practices through electrical diagram.

SWITCH

A **switch** is an electrical device used basically for controlling the current flow within the circuit. It is operated manually to turn **ON** (close) and turn **OFF** (open) a load such as lighting devices we have in our home.

Classification of switches base on their use:

1. General Use switches

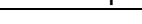
The General use switch is intended for use in the general distribution and branch circuit rated in amperes. It is capable of interrupting the rated current at a rated voltage.


2. General use snap switch

The General use snap switch is a form of general use switch installed in flush device boxes or an outlet box cover.

3. Isolating switch

The Isolation switch is a switch intended for isolating an electric current from the source of power.

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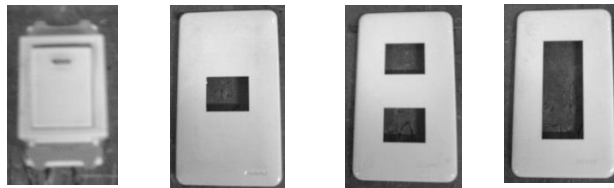
Classification of Switches based on their installation guidelines

- **Surface type.** This type of switch is installed above the surface of walls. It is used in exposed or surface type wiring method.




Surface Type Switch


- **Flush type.** This type of switch is installed within (imbedded) a wall and is used in flush or concealed type wiring method.



Concealed/Flush Type Switch with Gang Plates

The commonly used type of switch in house wiring installation is the single pole single throw or **SPST** switch. Consisting of both surface and concealed type, this switch is so useful in controlling (turn ON and OFF) one or more lighting loads, depending upon every possible need, in one location.


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The wall switch is one of the most common and important electrical devices in the home. There are several different types of switches, and although they may look the same when they are installed with their faceplates intact, the various switches look and function differently on the inside.

Most of the common types of switches come in different styles, such as toggle, rocker, slider, or push-button. The style usually does not affect the switch function and wiring. While switches usually are used for lights, they can be used to turn electrical current on or off for nearly any electrical device. For example, switches sometimes are installed to control the current running to an outlet in order to turn a floor lamp on or off.

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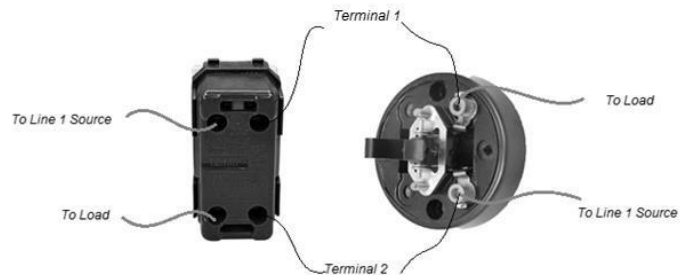
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Main Types of Electrical Switches

SPST Switch Connection S



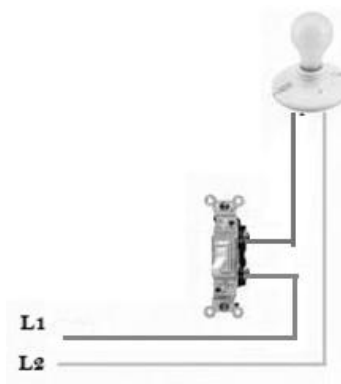
Claire Cohen





Wire Connection to Terminals

The **single-pole switch** is the general-purpose workhorse of switches. It is used to control a light, receptacle, or other device from a single location. A characteristic feature of a single-pole toggle switch is that it has *on* and *off* markings on the toggle. This is something you will not find on three-way or four-way switches.

This type of switch consists of two common terminals. Wires coming from the power source and the wire coming from the load can be connected to these terminals interchangeably without affecting the circuit.



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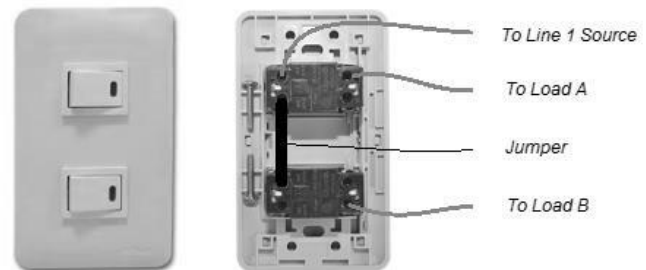
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Switch Connection

2-Gang Switch Connection S2

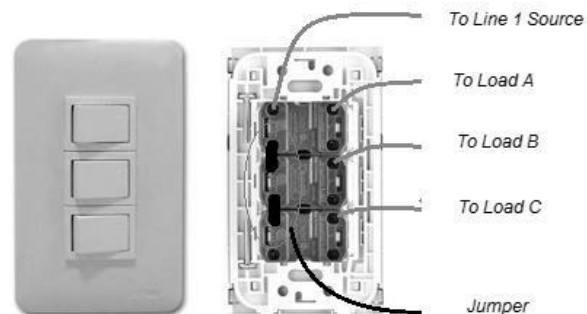
This consists of two SPST switches in a 2-gang plate. This is used to control two loads (load A and load B) individually in one location.


2-Gang Switch




3- Gang Switch Connection S3

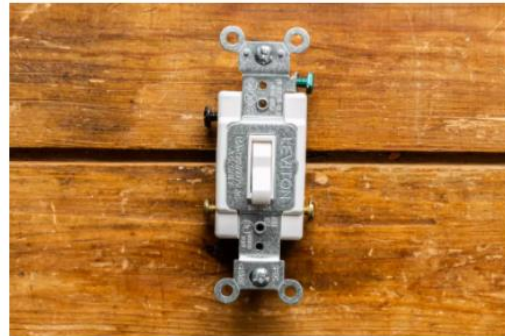
This consists of three SPST switches in a 3-gang plate. This is used to control three separate loads (load A, load B, and load C) in one location.



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Three-Way Switch



Claire Cohen

Three-way switches are always used in pairs and allow you to control a light or receptacle from two different locations. These switches have no on/off markings because the on and off positions will vary as the switches are used.

The three-way switch has three terminal screws. The hot wire from the power source connects to the darkest screw terminal marked "COM" for "common." The other two terminals are called travelers and are interchangeable. For purposes of safety, it is important to remember that travelers are always hot wires. The switch also has a ground screw.


3-Way Switch Connection S3W


3-way switch is a single pole double throw switch (SPDT switch) used to control a load in two separate locations. 3-way switch looks almost exactly like an SPST switch but differs in two things.

- Unlike SPST switch, 3-way switch does not have an ON indicator
- SPST switch has two common terminals, while 3-way switch has three terminals marked 0, 1, and 3.



ON indicator

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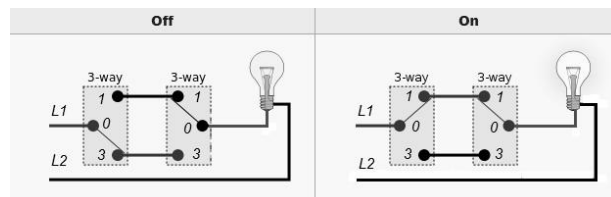
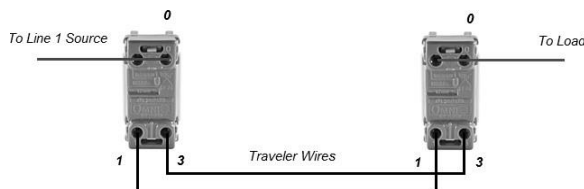
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3-Way Switch and SPST Switch Respectively

You will notice that the back of SPST switch does not have number indicator on its terminals. This means that you can connect wires (Line 1 and wire to Load) interchangeably. But not so in 3-way switch. It consists of three terminals marked by numbers 0, 1, and 3. To control a load in two separate locations, just like in a stairway and hallways, you need two pieces of 3-way switches. Traveler wires for terminals 1 and 3 can be connected inter-changeably but never on the 0 terminal.





Back Part of 3-way Switch and SPST Switch



Four Way Switch

Normally, we control a lighting fixture by a switch in one location. In our previous lesson, we learned that we could control one lighting fixture in two separate locations by using a 3-way switch. Now, we will look at a way to control one lighting fixture in three separate locations by using three separate switches. This is very useful in controlling lights on some stairways on different floors, or a light from garage that can be controlled in three separate areas of the house.

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To make this possible, we need two types of switches. We need two 3-way switches and one 4-way switch.



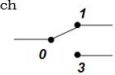
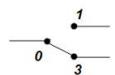


Switch Comparison

On the front face of SPST switch, 3-way switch, and 4-way switch, you will notice that they all look almost the same and can be flipped up and down. But when you look at the back, you will notice that they all differ in their terminals. SPST switch has two common terminals; 3-way switch has terminals marked as 0, 1, and 3; 4-way switch has terminals with markings of 1, 2, 3, and 4.





SPST 3-Way 4-way
Back of Switches

Looking inside the switches, you will see mechanical components that move when the switch is flipped up and down as shown in *Table 1*.

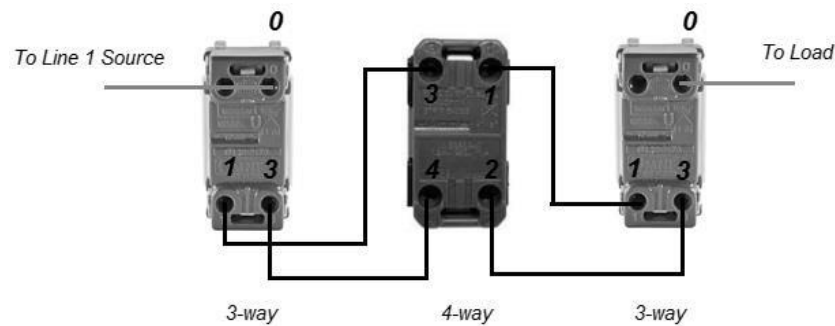
	Flipped UP	Flipped Down
SPST Switch		
3-Way Switch		
4-Way Switch		

4-way switch has a clever design when it comes to its mechanical component inside. When the switch is flipped, it crosses its track to change the direction of the flow of current. These two tracks do not touch, they are kept completely separated. By crossing its track to change the direction, we can therefore divert electric current and we can make or break the circuit.

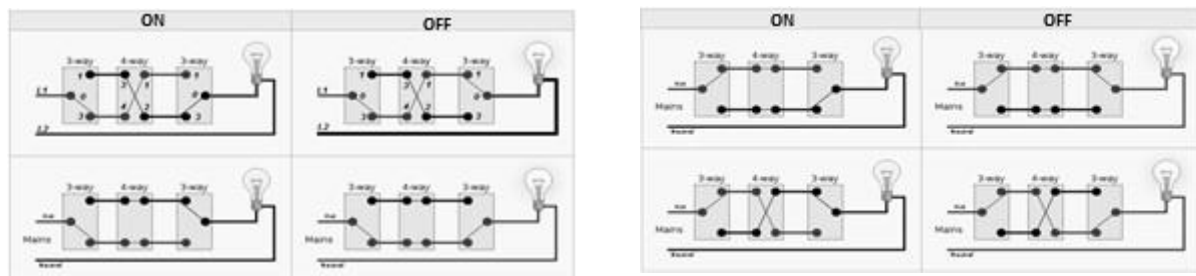
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4-Way Switch Connection S4W



Two pieces 3-way switch and one 4-way switch.





Flip Switch Anywhere to Control the Load

Note: Always observe terminal coding on both 3-way and 4-way switches in connecting the wire to avoid improper wiring installation.

PEC 4.4.1.8 (a)

All switches shall be located so that they may be operated from a readily accessible place. They shall be installed such that the center of the grip of the operating handle of the switch, when in its highest position, is not more than **1980 mm** above the floor or working platform.

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Pilot Switch

This switch has a toggle that glows when the fixture or appliance is on but out of sight and mind. Popular uses for a pilot switch include basement lights, outdoor lights, and remote appliances such as attic fans

Featured snippet from the web


Pilot light electrical devices for **switch** wall plates in residential and commercial locations. These illuminated **switches** are useful in situations where you want to be alerted that a device or load is on. ... Note that **pilot switches** are lighted when ON.




Dimmer Switch

These devices, sometimes called rheostats allow you to get maximum brightness from a light or any graduation. Dimmer also help save energy. Numerous designs are available. Some with preset and fade control. All dimmers are rated for maximum wattage

A rotary dimmer switch has sort of a fancy name, but it's something you're probably already familiar with. It's a dimmer switch with a dial on its face. They were pretty popular during

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the 1970s and 80s and are still widely available. So if you need a dimmer switch and you like the rotary action and somewhat retro look of a dial-type dimmer, this might be your next switch.

Uses

In case you're not familiar with rotary dimmers, the dial is used to control the amount of brightness of a light fixture. It can be adjusted from a very dim, moon-glow level, to the bulb's full brightness. The rotary knob turns from left to right. It's in the lowest setting when turned to the far left and at full brightness when turned to the far right. Most rotary dimmers have a push-on/off function. You push the dial straight in until it clicks to turn the light fixture on or off. Others turn all the way to the left until they click to turn on or off.

Heat Dissipation

A dimmer switch is basically a switch with a big variable resistor built into it. It consumes a little bit of energy, and this creates heat. To help dissipate the heat, the switches often come equipped with cooling fins or aluminum faces. Dimmers should be installed in electrical boxes that provide a little bit of breathing room, to prevent overheating. Don't cram one into a small switch box or a box that's full of wires. If you need to, you can replace the box with a deeper model. Use an "old work" box that's designed for remodeling. This allows you to install the box without cutting into the wall.


Wiring


Like other types of light switches, rotary dimmer switches can be wired to control lights from one, two, or three locations. One location calls for a switch. Two locations require a pair of matching three-way switches. Three locations require a four-way switch installed between a pair of three-way switches. Most dimmers have short wires, called *leads*, instead of the screw terminals you find on standard light switches. You connect the leads to the household circuit wiring using wire nuts.

Timer switch

Standard timer switches allow you to set a light, bathroom heater, or other device to turn on and off at predetermined times each day. Programmable timer switches take things one step further, providing multiple daily settings for security lights, a fan, even the TV. Unlike most other switches, some timer switches require a neutral wire, as well as the hot wire.

A time **switch** (also called a **timer switch**, or simply **timer**) is a **timer** that operates an electric **switch** controlled by the timing mechanism. ... The **switch** may be connected to an

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electric circuit operating from mains power, including via a relay or contactor; or low voltage, including battery-operated equipment in vehicles.

How **Timers Work**. As the dial advances, it triggers "on" and "off" trippers. These are bolted on the face of the dial and **turn** the **switch** "on" and "off" at the times you selected on the dial. ... The **switch** it controls is basically a single-pole **switch**, which is either "on" or "off".

Motion Sensor Switch


Used for security, convenience or energy saving, a motion-sensor switch turns on the light or lights when it detects movement in a room then shuts it off after a predetermined interval. Better designs allow you to adjust sensitivity and time interval and include a manual ON/OFF lever.

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