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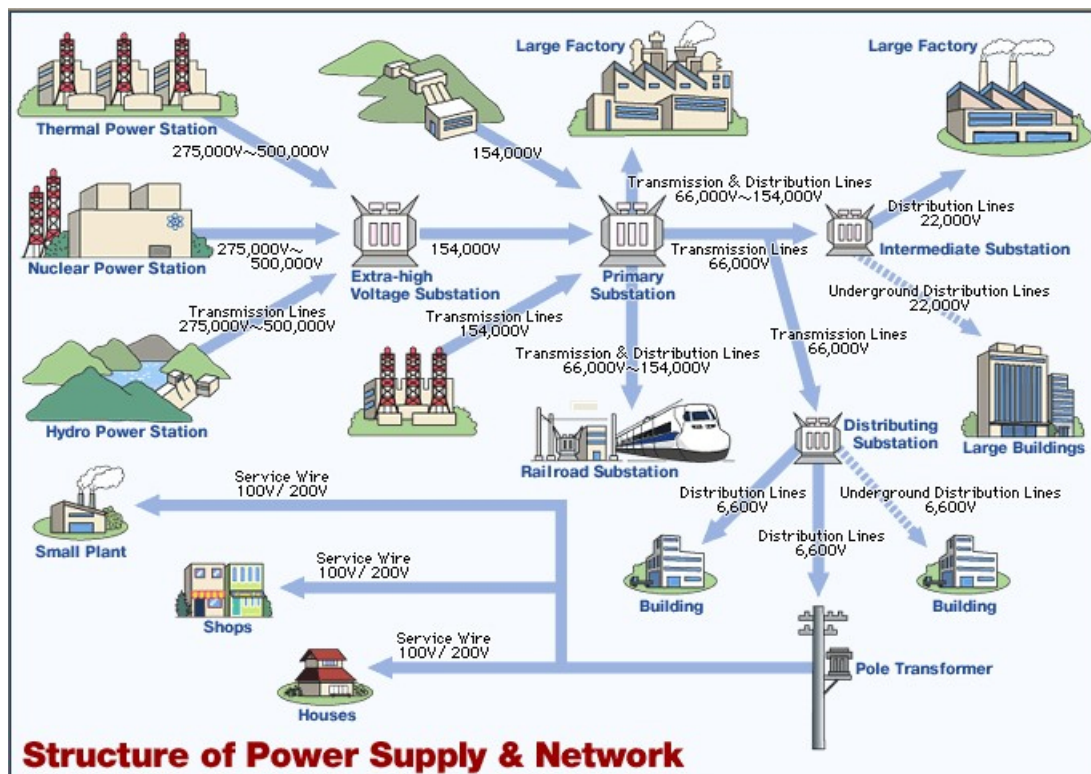
Department of Electrical Engineering

EE4092 Engineering Training II

Training Manual

(Electrical Installation)

Structure of power supply and network



Note: Process of generation, transmission, distribution, and consumption of electrical energy. The voltage values may vary, depending on each country.

Source: Tokyo Electric Power Company, <http://www.tepco.co.jp/en/challenge/energy/pow-net-e.html> (accessed July 26, 2013).

Three-Phase Electric Power

BY: CableOrganizer.com

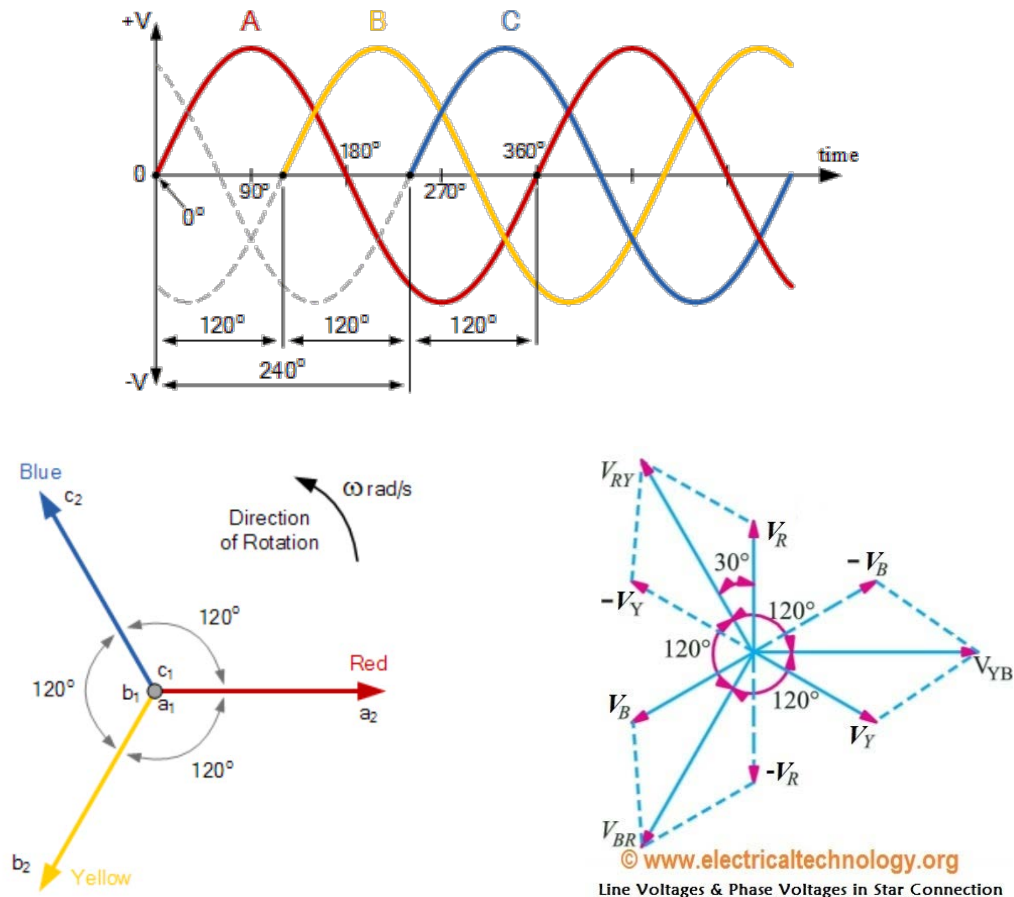
Three-phase electric power is a common method of electric power transmission. It is a type of polyphase system mainly used to power motors and many other devices. A three-phase system uses less conductor material to transmit electric power than equivalent single-phase, two-phase, or direct-current systems at the same voltage.

In a three-phase system, three circuit conductors carry three alternating currents (of the same frequency) which reach their instantaneous peak values at different times. Taking one conductor as the reference, the other two currents are delayed in time by one-third and two-thirds of one cycle of the electrical current. This delay between "phases" has the effect of giving constant power transfer over each cycle of the current, and also makes it possible to produce a rotating magnetic field in an electric motor.

Three phase has properties that make it very desirable in electric power systems. First, the phase currents tend to cancel out one another, summing to zero in the case of a linear balanced load. This makes it possible to eliminate the neutral conductor on some lines; all the phase conductors carry the same current and so can be the same size, for a balanced load. Second, power transfer into a linear balanced load is constant,

which helps to reduce generator and motor vibrations. Finally, three-phase systems can produce a magnetic field that rotates in a specified direction, which simplifies the design of electric motors.

Three-phase Waveform

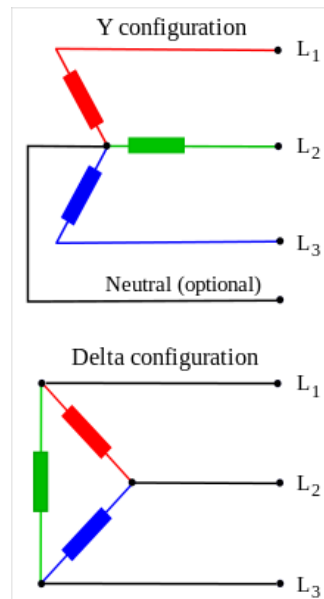


$$\begin{aligned}
 V_L &= |V_{RY}| = \sqrt{V_R^2 + V_Y^2 + 2V_R V_Y \cos 60^\circ} \\
 &= \sqrt{V_{ph}^2 + V_{ph}^2 + 2V_{ph} V_{ph} \times \frac{1}{2}} \\
 &= \sqrt{3} V_{ph} \\
 \therefore V_L &= \sqrt{3} V_{ph}
 \end{aligned}$$

Thus, the line voltage (380V) = $\sqrt{3} \times$ phase voltage (220V).

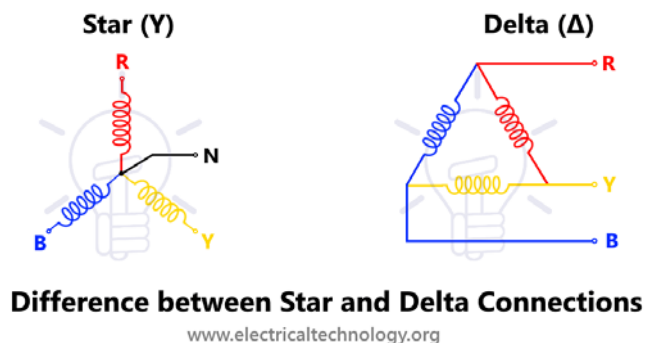
Three-wire and four-wire circuits

There are two basic three-phase configurations: wye (Y) and delta (Δ). As shown in the diagram, a delta configuration requires only three wires for transmission but a wye (star) configuration may have a fourth wire. The fourth wire, if present, is provided as a neutral and is normally grounded. The "3-wire" and "4-wire" designations do not count the ground wire present above many transmission lines, which is solely for fault protection and does not carry current under normal use.



Comparison between Star and Delta Connections

We mostly use the terms star and delta in electrical systems while discussing three phase AC circuits and electric motors. Below is a given table which compares both Star and delta connections showing the exact difference between Star (Y) and Delta (Δ) Connections.



HAZARDS OF ELCTRICITY

1. Electric Shock

Electric Shock is the physical stimulation that occurs when electric current passes through the human body. The injury depend on:

- The magnitude of the current
- The body parts through which the current flows
- Duration
- Physical condition of the person being shocked

1.1 Current Magnitude

The magnitude of the current which flows through the body generally obeys Ohm's law.

$$I = \frac{E}{R}$$

Where

I = current magnitude, amperes (A)

E = applied voltage, volt (V)

R = resistance of path through which current flows, ohm (Ω)

In Fig. 1 the worker has contacted a 220-V circuit when an electric drill short-circuits internally. The internal short circuit impresses 220 V across the body of the worker from the hand to the feet. This creates a current flow through the worker to the ground and back to the source. The total current flow in this case is given by the formula

$$I = \frac{E}{R_1 + R_2}$$

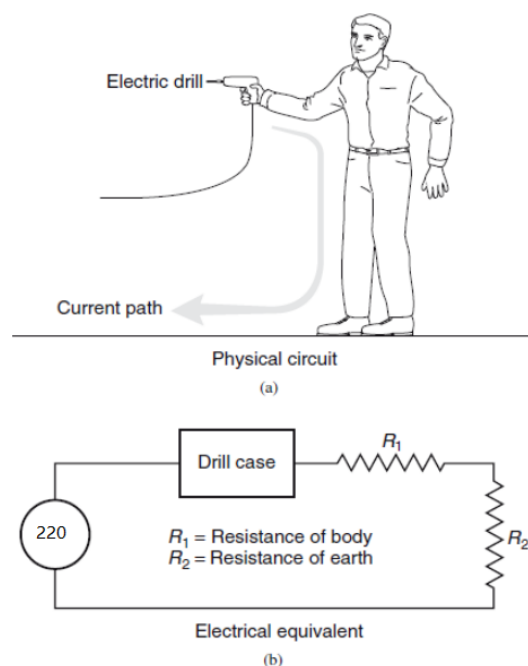


Figure 1 Electric shock current path

Variable R_2 is the resistance of the earth and for the purposes of this analysis may be ignored. Variable R_1 is the resistance of the worker's body and includes the skin resistance, the internal body resistance, and the resistance of the shoes where they contact the earth.

Condition (area to suit)	(Resistance) Dry	(Resistance) Wet
Finger touch	40 k Ω –1 M Ω	4–15 k Ω
Hand holding wire	10–50 k Ω	3–6 k Ω
Finger-thumb grasp*	10–30 k Ω	2–5 k Ω
Hand holding pliers	5–10 k Ω	1–3 k Ω

Palm touch	3–8 kΩ	1–2 kΩ
Hand around 1½-inch (in) pipe (or drill handle)	1–3 kΩ	0.5–1.5 kΩ
Two hands around 1½-in pipe	0.5–1.5 kΩ	250–750 Ω
Hand immersed	—	200–500 Ω
Foot immersed	—	100–300 Ω
Human body, internal, excluding skin	—	200–1000 Ω

Table 1 Nominal Resistance Values for Various Parts of the Human Body

1.2 Current Duration

The amount of energy delivered to the body is directly proportional to the length of time that the current flows; consequently, the degree of trauma is also directly proportional to the duration of the current.

Current flow through body tissues delivers energy in the form of heat. The magnitude of energy may be approximated by

$$J = I^2 R t$$

Where:

J = energy, joules

I = current, amperes

R = resistance of the current path through the body, ohms

t = time of current flow, seconds

If sufficient heat is delivered, tissue burning and/or organ shutdown can occur. Note that the amount of heat that is delivered is directly proportional to the duration of the current (t).

Current (60 Hz)	Physiological phenomena	Feeling or lethal incidence
<1 mA	None	Imperceptible
1 mA	Perception threshold	Mild sensation
1.3 mA		Painful sensation
3.10 mA		
10 mA	Paralysis threshold of arms	Cannot release hand grip; if no grip, victim may be thrown clear (may progress to higher current and be fatal)
30 mA	Respiratory paralysis	Stoppage of breathing (frequently fatal)
75 mA	Fibrillation threshold 0.5%	Heart action disorganized (probably fatal)
250 mA	Fibrillation threshold 99.5% (≥ 5 -s exposure)	
4 A	Heart paralysis threshold (no fibrillation)	Heart stops for duration of current passage; for short shocks, may restart on interruption of current (usually not fatal from heart dysfunction)
≥ 5 A	Tissue burning	Not fatal unless vital organs are burned

Table 2 Nominal Human Response to Current Magnitudes

2. Causes of Injury

Injury from electrical hazard can come from both direct and indirect sources:

- The reflex action caused by the passage of current flow can cause falls resulting in cuts, abrasions, or broken limbs.
- Nerve damage from shock or burns can cause loss of motor function, tingling, and/or paralysis.
- Burns, both thermal- and current-induced, can cause extremely long duration and intensely painful suffering. Third- and fourth-degree burns may require skin grafting to heal.
- The light intensity, molten metal, and/or burns to the eyes can cause blindness.
- The concussion of a blast can cause partial or complete loss of hearing.
- Current-induced burns to internal organs can cause organ dysfunction.
- The superheated plasma may be inhaled, causing severe internal burns.
- Metal vapors may be inhaled, filling the lungs with toxic residues.

3. Causes of Death

If the electrical injury is severe enough, death can result.

- An electric shock-induced fall can cause fatal physical injuries.
- When the skin is severely burnt, large quantities of liquid are brought to the burnt areas to aid in the healing process. This creates a stress on the renal system and could result in kidney failure.
- Severe trauma from massive burns can cause a general systemic failure.
- Burnt internal organs can shut down—causing death. Thus, the more critical the organ that is burnt, the higher the possibility of death.
- The pressure front from the blast can cause severe injury to the lungs, called **blast-lung**, resulting in death.
- Heart failure can result from fibrillation and/or paralysis.

Workplace Hazards

General Electrical Safety Rules

When working with possibly energized equipment, a second person capable of helping in an emergency must be present. This is not intended to apply to hand tools or completely enclosed conventional electronic equipment.

- Never handle electrical equipment when hands, feet, or body are wet or perspiring or when standing on a wet floor.
- When it is necessary to touch electrical equipment (for example, when checking for overheated motors), use the back of the hand. Thus, if accidental shock were to cause muscular contraction, you would not “freeze” to the conductor.
- Avoid wearing rings, metallic watchbands, etc.
- When operating circuit breaker, use only one hand; keep clear of everything except operating handles; turn your face away before operating the breaker; don’t operate isolating switches under load.

1. Barriers and Signs

Whenever work is being performed that requires the temporary removal of normal protective barriers such as panels or doors, barriers and signs should be used to warn personnel of the hazard.

1.1 Barrier Tape

Barrier tape is a continuous length of abrasion-resistant plastic tape. It should be a minimum of 50mm wide and should be marked or colored to clearly indicate the nature of the hazard to which employees will be exposed if they cross the tape line. Such tape should be yellow or red to comply with Occupational Safety and Health Administration (OSHA) standards.



Figure 2 Barrier tape styles suitable for electrical hazards.

1.2 Signs

Warning signs should be of standardized design and easily read. They should be placed in such a way as to warn personnel of imminent hazard.



Figure 3 Typical electrical hazard sign.

2. Safety Tags, Locks, and Locking Devices

Safety tags, locks, and locking devices are used to secure and mark equipment that has been taken out of service. They are applied in such a way that the equipment cannot be reenergized without first removing the tags and/or locks.

2.1 Safety Tags

Safety tags are applied to equipment to indicate that the equipment is not available for service. They are tags constructed of a durable, environment-proof material. They should be of standardized construction and include an "action statement" warning that says Do Not Start, Do Not Open, Do Not Close, Do Not Operate, or other such warning. The tag must also indicate who placed it on the equipment and the nature of the problem with the equipment. Some manufacturers supply tags with individual employee photographs on them. This type of tag helps to further identify who placed the tag and to personalize the installation.



Figure 4 Typical tags suitable for tagout purposes.

2.2 Locks and Multiple-Lock Devices

Locks are used to prevent operation of equipment that has been de-energized. They must be strong enough to withstand all but the most forceful attempts to remove them without the proper key. If a lock can be removed by any means other than a bolt cutter or the key that fits it, the lock should not be used.



Figure 5 Typical padlocks, Multiple-lock devices



Maine Farm Safety Program

by Dawna L. Cyr, farm safety project assistant, and Steven B. Johnson, Ph.D., Extension crops specialist

First Aid for Electrical Accidents

First Aid for Electric Shock Victims

1. Don't touch them!
2. Unplug the appliance or turn off the power at the control panel.
3. If you can't turn off the power, use a piece of wood, like a broom handle, dry rope or dry clothing, to separate the victim from the power source.
4. Do not try to move a victim touching a high voltage wire. Call for emergency help.
5. Keep the victim lying down. Unconscious victims should be placed on their side to allow drainage of fluids. Do not move the victim if there is a suspicion of neck or spine injuries unless absolutely necessary.
6. If the victim is not breathing, apply mouth-to-mouth resuscitation. If the victim has no pulse, begin cardiopulmonary resuscitation (CPR). Then cover the victim with a blanket to maintain body heat, keep the victim's head low and get medical attention.

First Aid for Electrical Accidents

- **Disconnect the appliances or turn off the power if a person is undergoing electric shock.**
- **Cover associated electric shock burns with a dry sterile dressing only.**
- **Never touch a person undergoing electric shock or you too could become a victim.**



Maine Farm Safety Program

First Aid for Electrical Burn Victims

Electrical burns vary in severity depending upon: (1) how long the body is in contact with the electric current; (2) the strength of the current; (3) the type of current; and (4) the direction the current takes through the body.

Often these burns are deep. There may be more than one area burned. One area may be where the current entered the body and another may be where it left. Electrical burn wounds may look minor on the outside, but could be severe on the inside.



If a person has received an electrical burn, check for shock and follow the steps outlined on page 1. If the person is conscious and there are no signs of shock (such as being cold, clammy, pale and having a rapid pulse), begin treating the burned area. Do not apply grease or oil to the burn. Cover the burn with a dry, sterile dressing, but do not cool the burn. Keep the victim from getting chilled. Seek medical attention as soon as possible.

This Maine Farm Safety fact sheet is part of an educational fact sheet series produced by University of Maine Cooperative Extension. For more information on farm safety, contact your county Extension office.

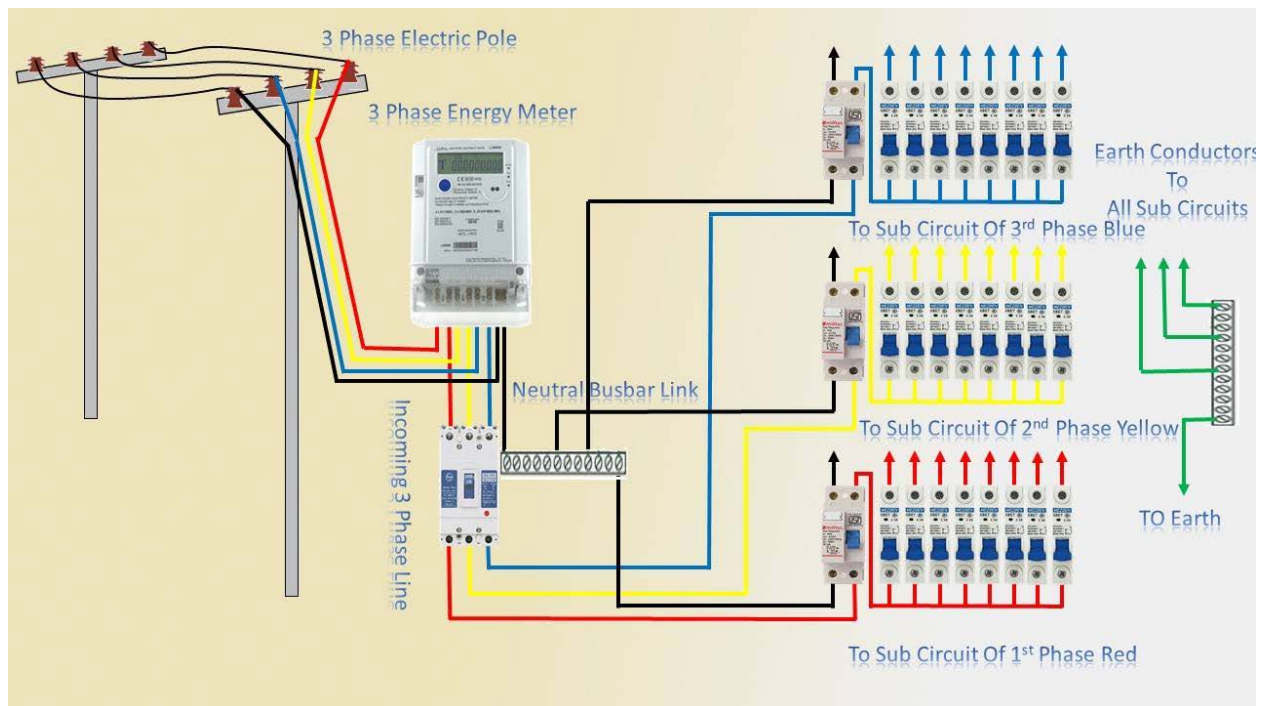
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3-Phase & 1-Phase Electrical Distribution Wiring Installation in Home



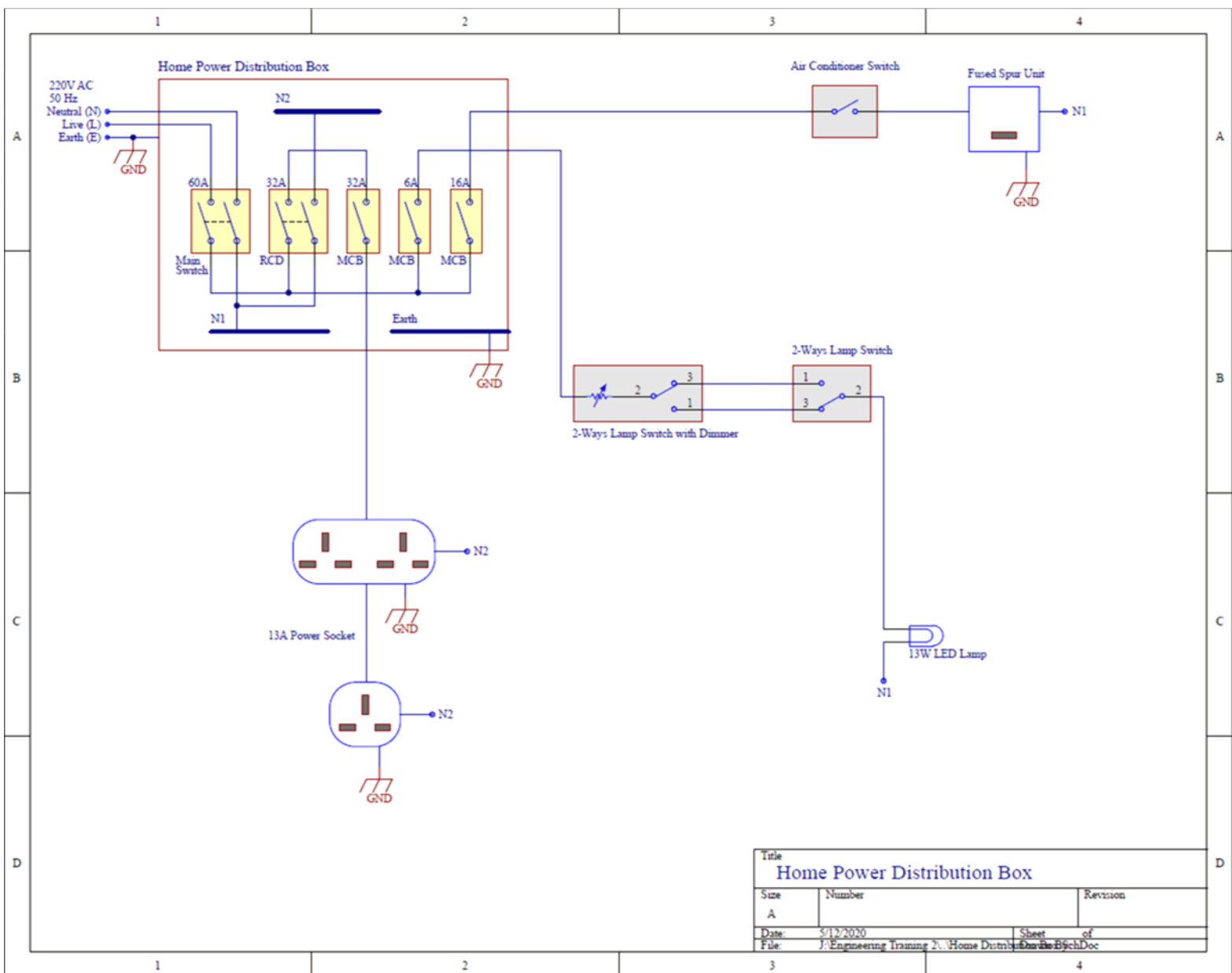
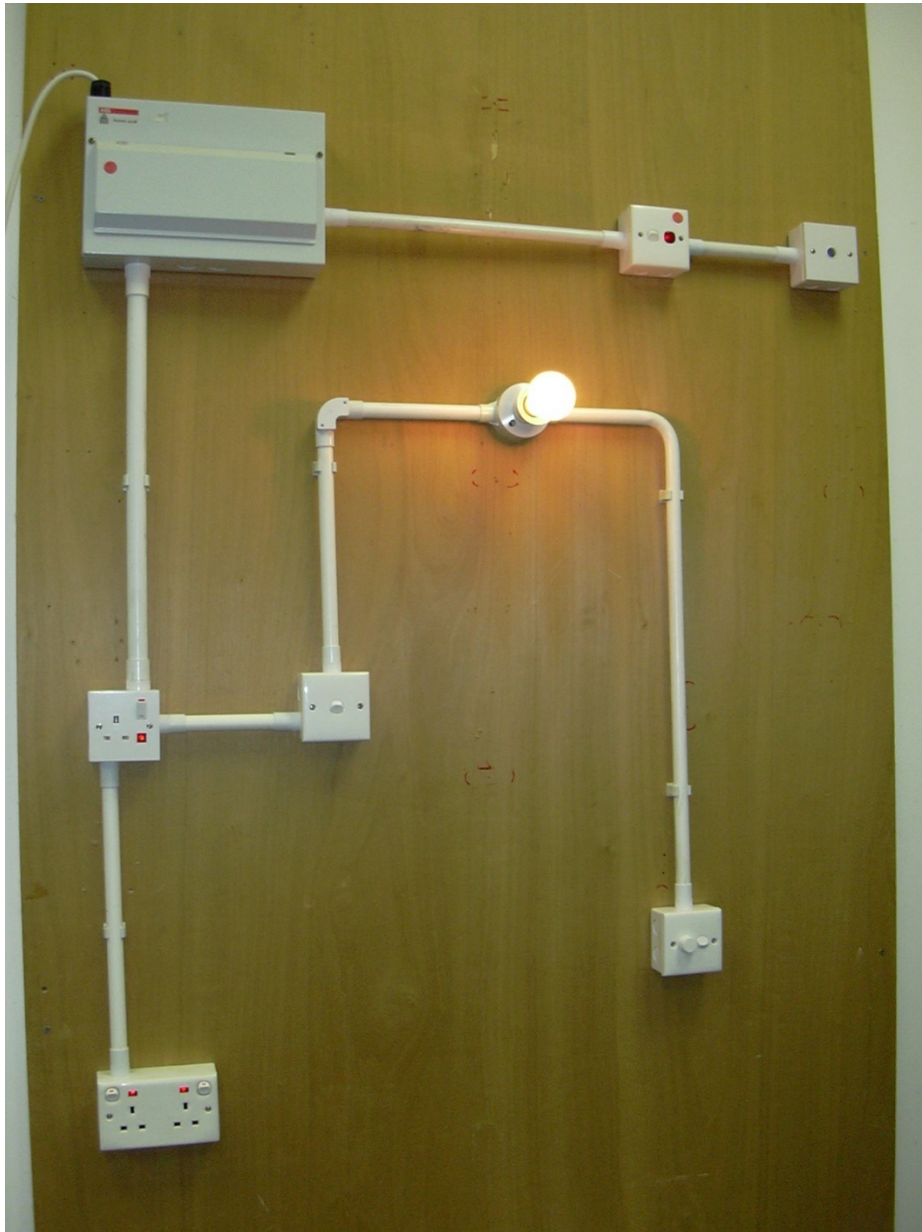
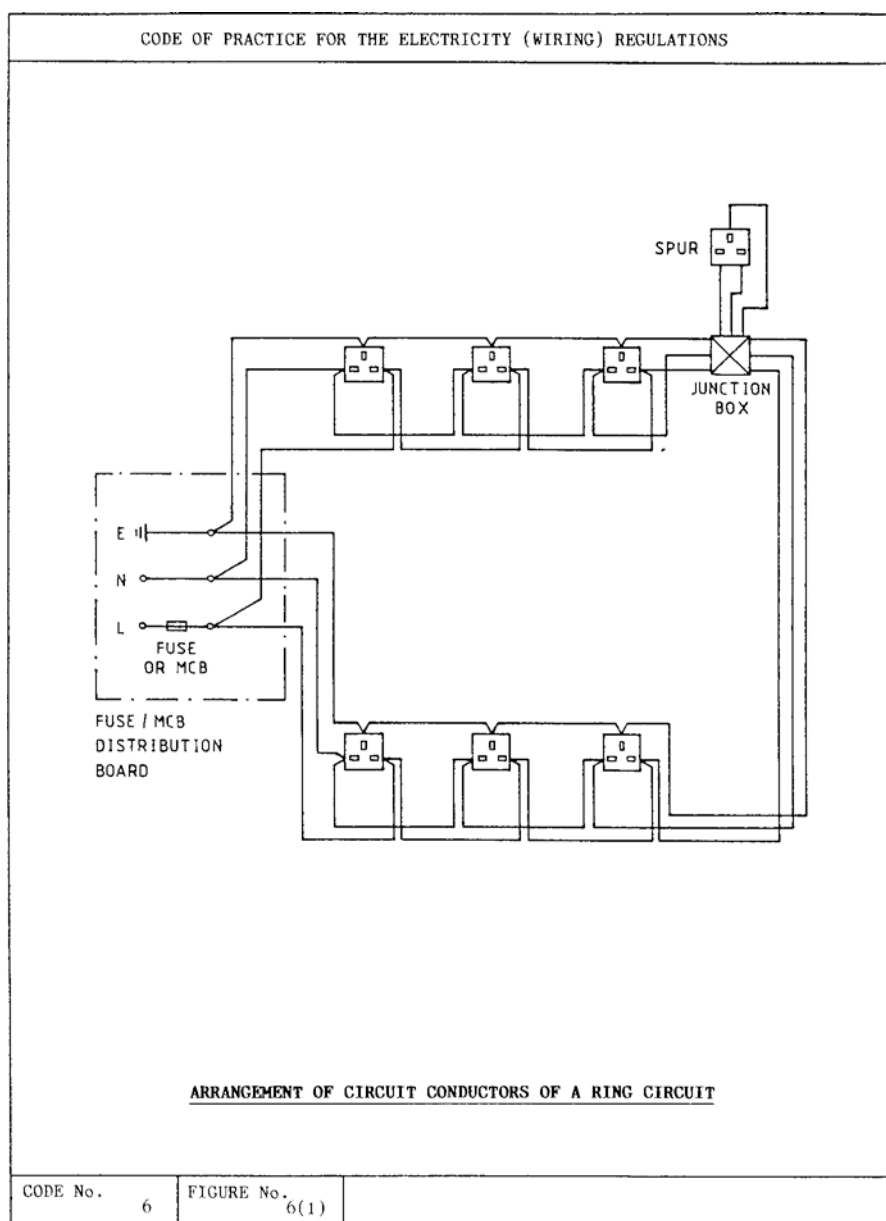


Figure 6 Home Power Electrical Distribution Box



Type of Circuit	Rating of Overcurrent Protective Device (HBC fuse or Miniature Circuit Breaker)	Min. Copper Conductor Size of Rubber or PVC Insulated Cable for the Circuit and Non-fused Spur (Note)	Maximum Floor Area Served
A1 Ring	(Ampere) 30 or 32	(mm ²) 2.5	(m ²) 100
A2 Radial	30 or 32	4	50
A3 Radial	20	2.5	20

Table 3 Final Circuits Using 13A Socket Outlets



MCB Rating (Amp)		5	10	15	20	30	50	60	80	100
Minimum cross-sectional area (sq.mm) of protective conductor for 5 sec. (not including within 0.4 sec.) disconnection	Copper	1	1.5	2.5	2.5	4	10	10	16	16
	Aluminum	16	16	16	16	16	16	16	16	25

Table 4 Minimum Cross-sectional Area of Protective Conductor for Circuit Protected by Miniature Circuit Breaker (MCB) Type 3

Current Rating (Amp)	1-Phase, 2-Wire							3-Phase, 4-Wire									
	5	15	20	30	60	80	100	5	15	20	30	60	100	150	200	300	400
Enclosed Condition	1.0	2.5	2.5	4	16	25	35	1.0	2.5	2.5	6	16	35	70	120	240	400
Clipped Direct	1.5	2.5	2.5	4	10	16	25	1.5	2.5	2.5	4	10	25	50	70	150	240

Table 5 Minimum Size of PVC Copper Conductors in sq. mm under the General Installation Conditions

References:

- *Electrical Safety Handbook, Fourth Edition* (Blacklick: McGraw-Hill Publishing)
- Tokyo Electric Power Company, <http://www.tepco.co.jp/en/challenge/energy/pow-net-e.html> (accessed July 26, 2013)
- <https://www.cableorganizer.com/learning-center/>
- <https://www.electricaltechnology.org>
- *The University of MAINE Cooperative Extension* (by Dawna L. Cyr, farm safety project assistant, and Steven B. Johnson, Ph.D., Extension crops specialist)
- *Hong Kong EMSD (Code of Practice for the Electricity (Wiring) Regulations 2015 Edition)*

BUZZ IT

13A SOCKET TESTER

SAFETY WARNING

Proper safety measures should be taken when working with voltages exceeding 30V AC rms, 42V AC peak or 60V DC. Your socket tester is not intended to replace good electrical practices. This unit must only be used under the conditions and for the purposes for which it has been constructed. Pay attention to these safety instructions, the technical specification and the use of the unit in dry surroundings.

PRE-TEST CHECK

Visually inspect the socket tester for any signs of physical damage, e.g. cracks, splits, loose pins or damaged indicators, etc. In the unlikely event of the socket tester sustaining physical damage, it should not be used. For good electrical practice it is recommended that you verify the function of the tester on a known correctly-wired live socket before and after use.

N.B. The Buzz-it may emit a slight beep when initially plugged in. This should be ignored.

OPERATING INSTRUCTIONS

Simply plug the BZ101 Buzz-it Socket Tester into a live 13A socket and switch the socket on. Three indicator LED's across the front of the unit provide a clear indication of a correctly wired socket. In addition to the three indicator LED's the Buzz-it generates a continuous tone when the socket wiring is correct. Fault indications are quickly identified using the key on the face label. Additional information can be found in the table opposite, showing 32 wiring conditions, of which 28 are faults that require investigation. The Buzz-it tone will not sound if a Fault indication is present.

The BZ101 Buzz-it Socket Tester can also be used as a simple fuse-finder: If the unit is plugged into a live correctly-wired socket, such that the continuous tone is heard, the tone will cease when the correct fuse or breaker is disconnected at the fuse-board.

STORAGE AND MAINTENANCE

The socket tester should be kept in warm, dry conditions and should be protected from moisture, physical damage and direct sources of heat. Ensure the unit is dry before use.

Cleaning: After removal from any socket, the unit may be cleaned using a soft, dry cloth. Solvents, liquids, detergents, surfactants and waxes should not be used. There are no user serviceable parts inside.

WARRANTY

This item is warranted against defects in materials and manufacture for 24 months from the date of purchase. Return to Martindale Electric if faulty.

 Equipment complies with relevant EU Directives

 Caution - risk of danger & refer to instructions

 Equipment protected by double or reinforced insulation (Class II)

 End of life disposal of this equipment should be in accordance with relevant EU Directives

TECHNICAL SPECIFICATION

Operating voltage: 230V
Frequency: 50Hz
Power consumption: <2.7W
Temperature range: -10 to 40°C at max, 60% RH
Pollution degree: 2
Power supply: from mains
Open Earth if Earth resistance >50k Ohm nom at 230VAC nom
Open Neutral if Neutral resistance > 50k Ohm nom at 230VAC nom
Earth Leakage <5mA on a correctly wired socket
Complies with BS EN61010

CAT II is for equipment intended to be supplied from the building wiring. It applies both to plug-connected equipment and to permanently connected equipment.

~ Alternating Current (ac)

Martindale Electric Co Ltd
Metrohm House
Penfold Trading Estate
Imperial Way
Watford
WD24 4YY

N	E	L
Socket Wires		
N	E	L
N	N	L
E	E	L
E	N	L
L	E	N
L	E	E
L	N	E
L	N	N
E	L	L
N	L	L
N	OPEN	L
E	OPEN	L
L	OPEN	E
L	OPEN	N
OPEN	E	L
OPEN	N	L
OPEN	L	E
OPEN	L	N
N	L	E
E	L	E
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L	N	L
OPEN	OPEN	L
OPEN	L	OPEN
L	OPEN	OPEN
OPEN	L	L
L	OPEN	L
L	L	OPEN
OPEN	OPEN	OPEN
L	L	L

BZ LED's		
OK	● ● ●	
Note 1	● ● ●	
Note 1	● ● ●	
Note 1	● ● ●	
LN Reverse	● ●	Note 2
LN Reverse	● ●	Note 2
LN Reverse	● ●	Note 2
LN Reverse	● ●	Note 2
LN Reverse	● ●	Note 2
LN Reverse	● ●	Note 2
No Earth	● ●	Note 2
No Earth	● ●	Note 2
No Earth	● ●	Note 2
No Earth	● ●	Note 2
N Fault	● ●	Note 2
N Fault	● ●	Note 2
N Fault	● ●	Note 2
N Fault	● ●	Note 2
LE Reverse	●	Note 2
LE Reverse	●	Note 2
LE Reverse	●	Note 2
LE Reverse	●	Note 2
LE Reverse	●	Note 2
EN Fault		Note 3
LEN Fault		Note 3
LEN Fault		Note 3
LEN Fault		Note 3
LEN Fault		Note 3
LEN Fault		Note 3
L Fault		Note 3

With reference to table:

Note 1
EN reversal not detectable

Note 2
Investigation required by qualified electrician.

Note 3 Caution!
Investigate with care. Socket wire(s) may be live, but LED's will not light.
Investigation required by qualified electrician.

NOTE: This unit, in common with other simple socket testers, cannot detect Earth/Neutral reversal.



ENGLISH

Datasheet

Stock No. 123-2240

IRT 1900

DIGITAL RCD TESTER



FEATURES

- ❑ Custom microprocessor controlled for highest accuracy and reliability.
- ❑ 3 LED 's for checking correct wiring status.
- ❑ 0 and 180 degree phase angle switch permits quick tests and consistent readings.
- ❑ Digital read out of tripping time.
- ❑ Large custom digital display readout on all models.
- ❑ Visual indication of reversed phase and neutral wiring at socket.
- ❑ Resilient case made from modern plastics to take everyday knock and bangs.

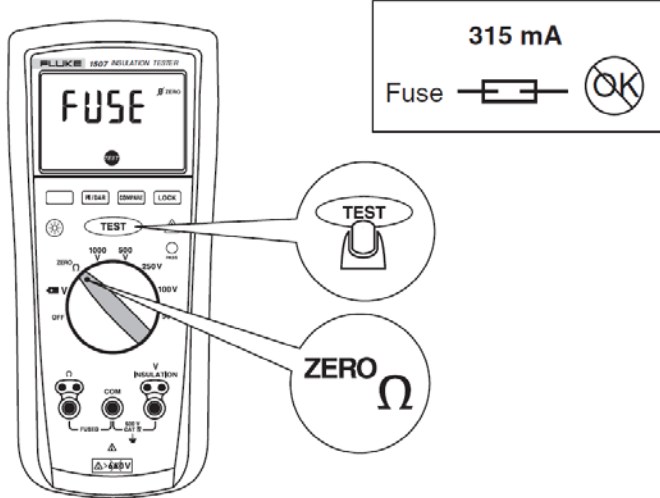
SPECIFICATIONS

Rated Tripping Current	10 / 20 / 30 / 100 / 300 / 500mA
Fault Condition Setting	x1/2 , x1 , x5
Fault Trip Time	2000ms, 40ms (x5)
Low Set Resolution	1ms (x1/2 , x1) , 0.1ms (x5)
Trip Time Accuracy	$\pm(1\%rdg + 2dgts)$,x1/2, x1 $\pm(1\%rdg+20dgts)$, x5
Operating Voltage	230V $\pm$ 10% , 50/60Hz
Display Hold Time	Grater than 5s on loss of power
Dimensions	180x130x70 mm
Weight	Approx. 800g
Operating Temperature and Humidity	0 to 40°C (32 to 104°F), Below 80% RH
Storage Temperature	-10 to 60°C (14 to 140°F)
Accessories	Test Lead with IEC Connector, Neck Strap and Instruction Manual.

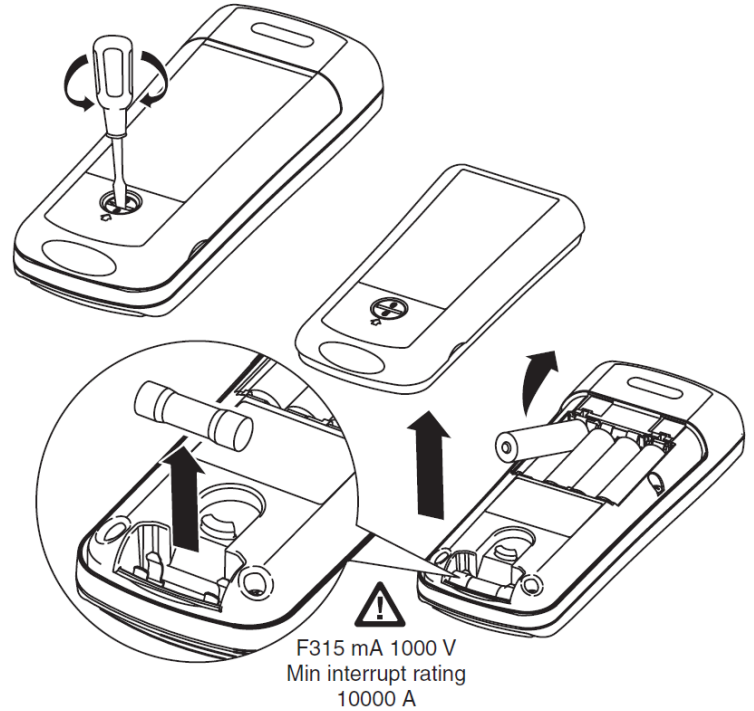
1507/1503 Insulation Tester Quick Reference Guide

⚠ See Users Manual for "Safety Information" and complete operating information.

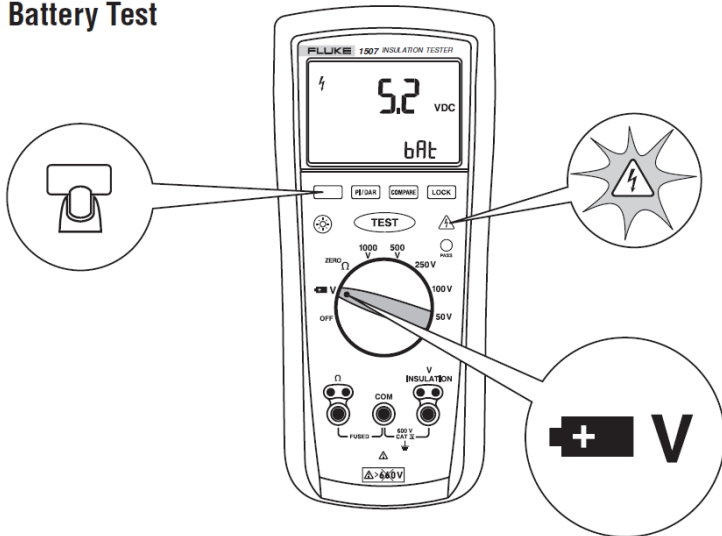
Fuse Test



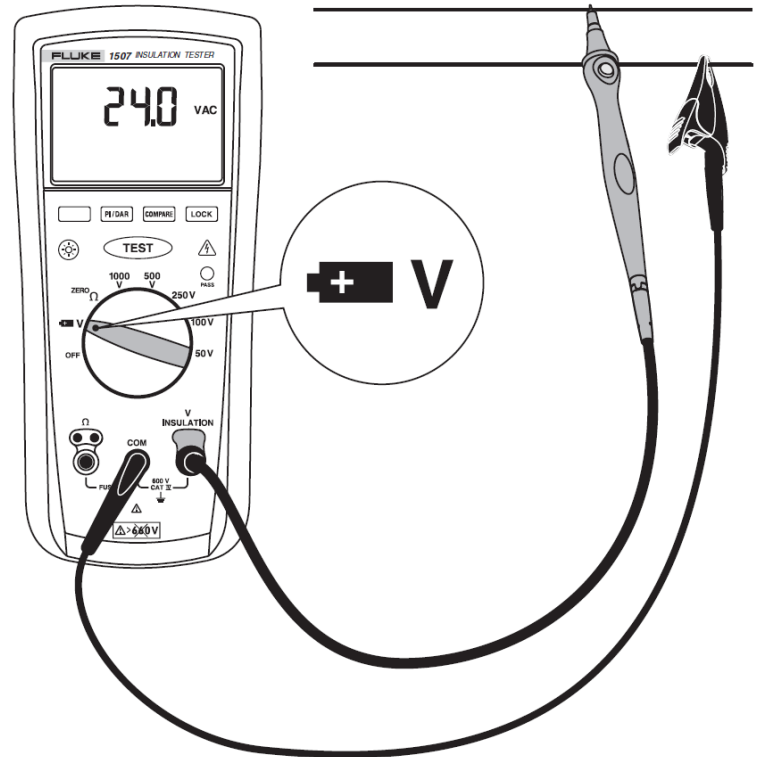
Battery and Fuse Replacement



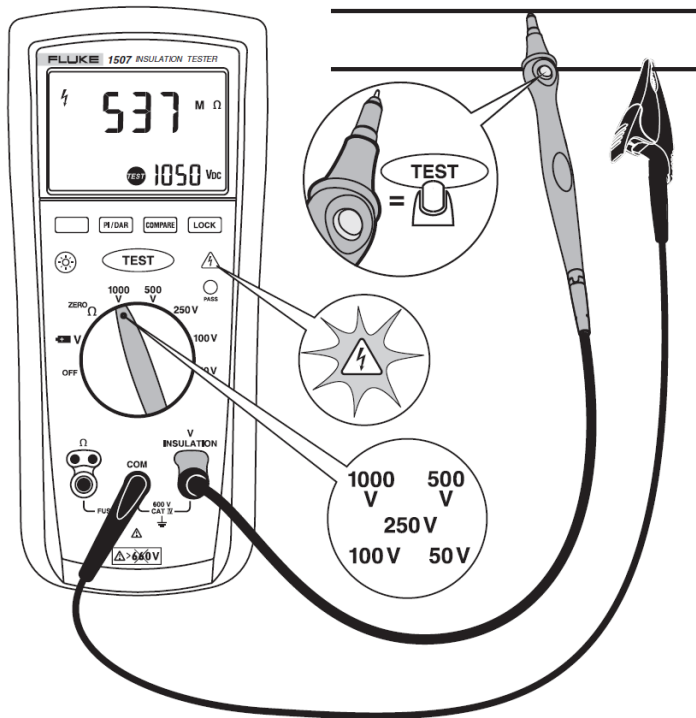
Battery Test



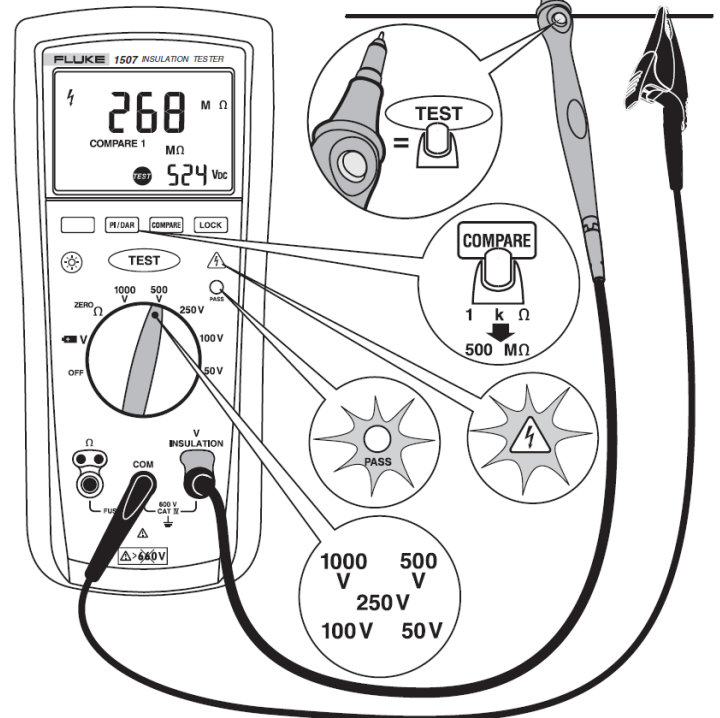
Voltage



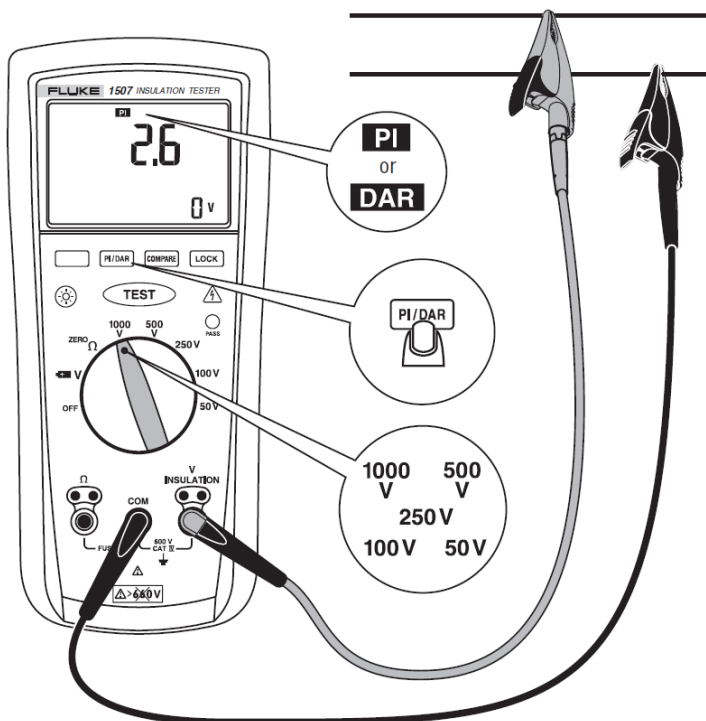
Measuring Insulation Resistance



Compare Function (1507)



Polarization Index and Dielectric Absorption Ratio (1507)



Measuring Earth-Bond Resistance

