

# Protective Measures Against Electric Shock

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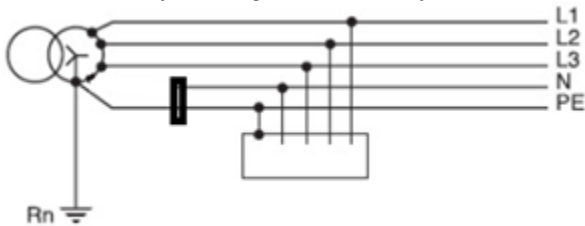
**Abstract:** Because it is a serious matter in electrical installations our Knowledge in protective measures should be always refreshed so we can save lives and properties from electrical hazards.

## The basic names for low voltage systems:

We distinguish between the low-voltage systems types according to the grounding of both the source and the exposed conductive units in the system There are three main types: TN, TT, and IT

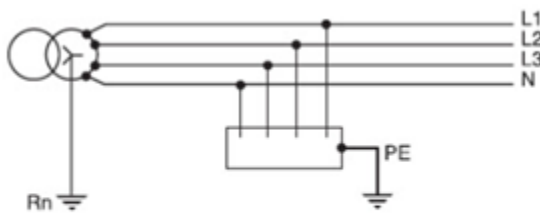
### 1-TN system:

In TN system the star point of the secondary windings of the source transformer is grounded and every exposed conductive part of any apparatus in the system is connected directly to the ground of the system.



### 2-TT system:

The difference here is in exposed conductive parts of any apparatus in the system is grounded separately from the system (i.e. has its own ground).



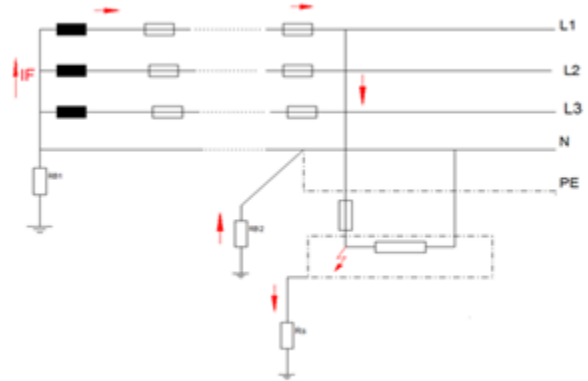
**TT**

### 3- IT system:

The secondary of the transformer her is not grounded but the exposed conductive parts of any apparatus in the system is grounded separately from the system (i.e. has its own ground).

## Terms and definitions relating to protective measures:

- 1- An insulation fault is a faulty state in insulation.
- 2- A ground contact is an accidental electrical connection formed between a body (e.g. a metal housing) and live parts of electrical equipment.

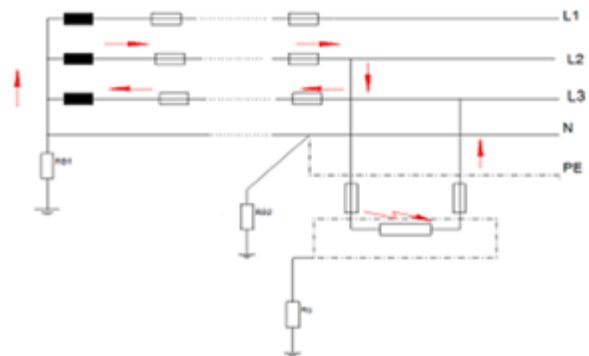


IF: fault current

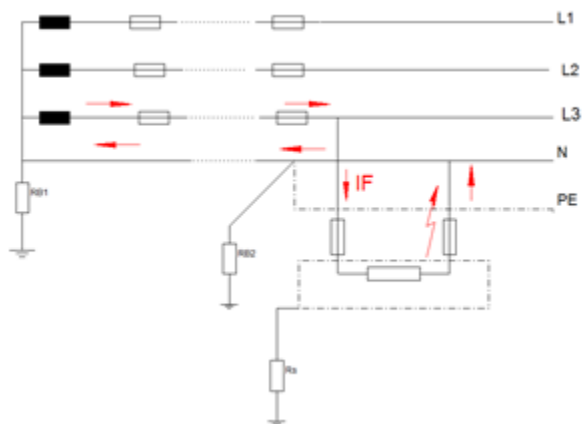
RB: Resistance of the service grounding electrode

RS: resistance of the protective grounding electrode

- 3- A short circuit is an accidental electrical connection between operationally live conductors, when there is no active resistance in the fault circuit.

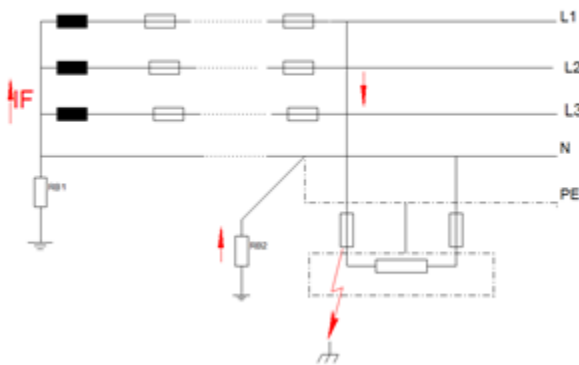


- 4- A conductor short-circuit is an accidental connection between operationally energized conductors when there is an active resistance



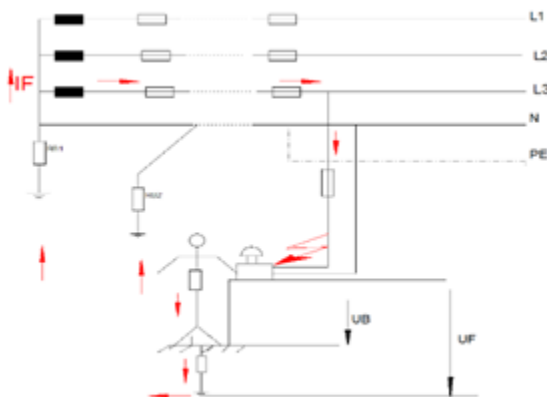
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5- A short-to-ground is any accidental electrical connection, including arcing, between an outer conductor or an insulated mid-point conductor and ground or grounded components



- 6- A fault voltage  $U_F$ : Is the accidental voltage occurring between physical objects and the reference ground.
- 7- A contact voltage  $U_B$ : is the fault voltage which can be bridged by a human body.
- 8- A fault current  $I_F$ : is the current which flows because of an insulation fault.
- 9- A leakage current: is the current which during normal operation flows from active parts of electrical equipment via normal undamaged insulation to non-active parts electrically connected to the mid-point conductor or to ground.

This illustration explains points 6-7-8



**protection classes for electrical equipment**

Class	Description	Example
Protection class I	Protective measure using protective conductor symbol	Equipment with metal housing e.g. electric motor
Protection class II	shockproof insulation symbol	Equipment with plastic casing e.g. domestic appliance
Protection class III	Protective low voltage symbol	Equipment with a rated voltage up to 42 v or 6 V e.g. electrical hand lamps

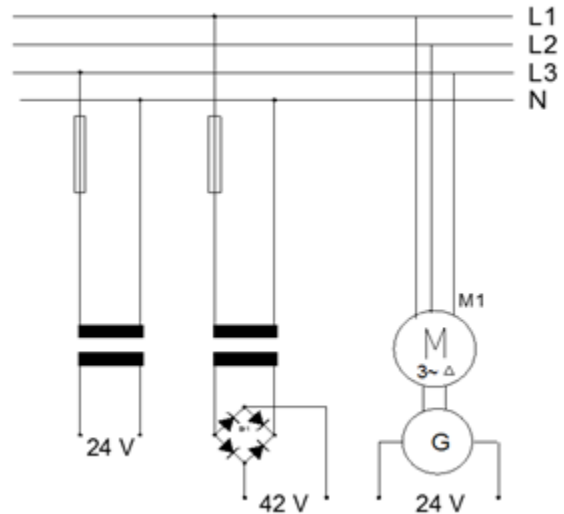
**Measures of protection against direct or indirect contact:**

**1- Protection through Protective Extra-Low Voltage PELV:**

This is used in circuits which not having special protective conductor, and for this purpose we use:

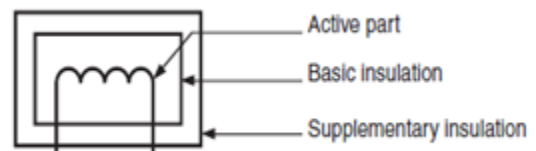
- Safety transformer
- Motor generator with insulated windings
- Electrochemical supply (e.g. battery)
- Electronic power supply unit with protected output

In this case the output voltage will be 42, 24, or 12 volts



**2- Insulation protection:**

Here appliances are referred to having “double insulation and No conductive parts of the appliance will be connected to a protective conductor.



**3- Protective Measures relying on automatic disconnection**

This can be used in direct and indirect contact for the most common TN and TT systems

**3-1 – Automatic disconnection for TN system:**

To ensure that any insulation fault (full ground contact) will cause the circuit to be opened by over current protective devices or RCDs (Residual Current Devices), circuit-breaker or fuses.

In this case the earth fault current will be:

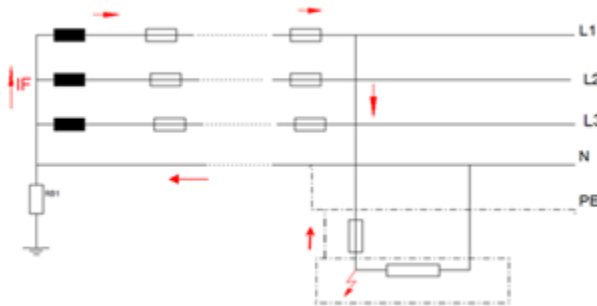
Where:  $U_E$  = the nominal phase to neutral voltage  
 $Z_{Sch}$  = the earth – fault current loop impedance

Example:

The case number 2 of the terms (ground contact):

Dennis Neitzel. Electrical Safety Handbook, Second Edition. McGraw-Hill, Inc. 2000

[4]. Mastrullo, Kenneth G., Jones, Ray A., Jones, Jane G., The Electrical Safety Program Book, National Fire Protection Association, Inc., Quincy, MA., 2003.



$$Z_c = Z_T + Z_L + Z_B + Z_U$$

( $Z_T$  = Active impedance component of transformer winding

$Z_L$  = impedance of the outer conductor

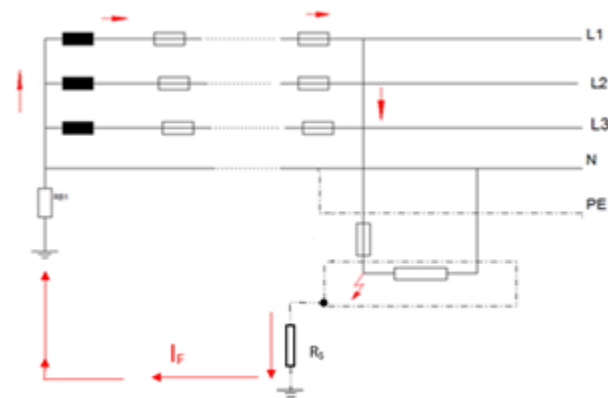
$Z_B$  = service grounding impedance

$Z_U$  = contact impedance)

By calculating  $I_F$  we can determine the instantaneous magnetic trip unit adjustment of the circuit-breaker.

**3-2 – Automatic disconnection for TT system:**

After an insulation fault, the protective grounding in TT system causes the fault current to flow from the grounded housing of an electrical appliance via the service grounding point through the ground to the grounding point of the transformer.



Where:  $R_S$  is the resistance of the protective grounding electrode for the installation.

$I_{\Delta n}$  is the rated residual operating current of the RCD

For work site and agricultural premises, the value of: 50 V is replaced by 25 V.

**Conclusion:**

Because of the serious effects due to the electric shock like: disturbances of heart, nervous paralysis, muscular paralysis, or others. It very important enhance our knowledge of the protective measures against the electric shock.

**References:**

[1]. EIG – F – Protection – electric – shock  
 [2]. Siemens (protection against electric shock)  
 [3]. Cadick, John, Mary Capelli-Schellpfeffer, and