Electrical Safety

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Introduction

- Electrical Hazard

Electrical excitation of tissue – current, voltage, frequency

Electrical power transfer – burns

Electrical Instruments

Grounding instruments

Patient protection – electrical isolation

Isolation transformers

Optical, magnetic and capacitive isolation

Safety

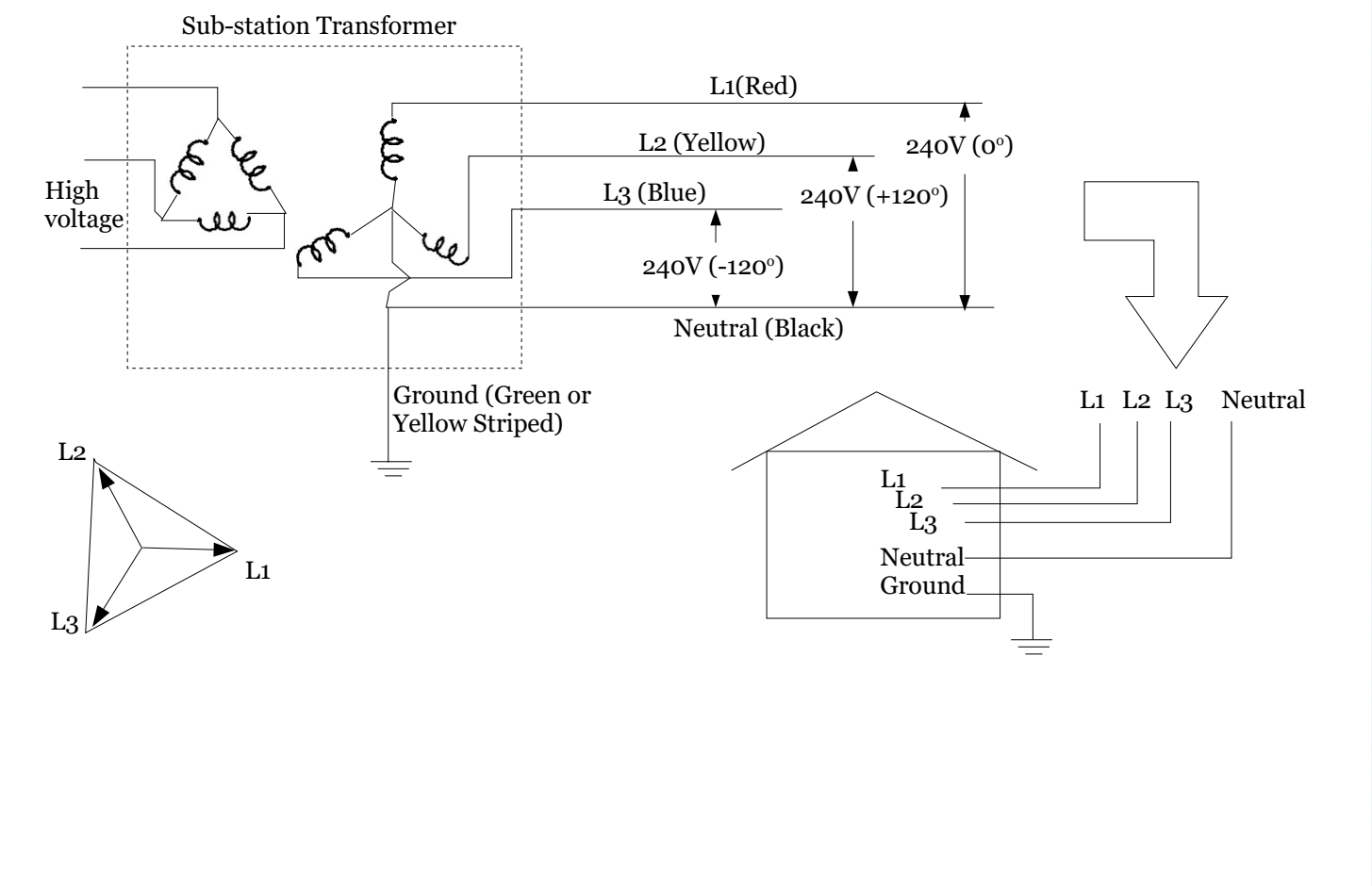
- Electrical Safety in Hospitals
- The Mains Power Distribution
  - Electrical power distribution – three phase and single phase systems
  - Ground – Sub-station ground, local ground, neutral
- Leakage Current Detection and Protection Devices
- Ground Fault Circuit Interrupter (GFCI) or Residual Current Circuit Breaker (RCCB)

Danger to Humans – Biological reasons

- Electrical Danger to Humans

Electrical Stimulation of nerves and muscles
Skeletal Muscle contraction
Cardiac Muscle fibrillation

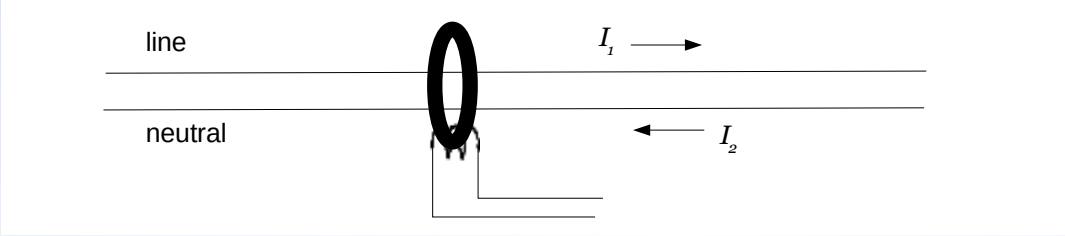
3 Phase Mains Power



Mains Power

- In India the nominal phase voltage is 240V @ 50Hz. (Voltage between any two phases is 415V)
- The Neutral is Ground-connected at the sub-station.
- The Neutral is the current return line for a single phase line.
- In a building, the individual power points are connected to Ground.
- All instrument bodies are connected to Ground.
- The Ground and Neutral should be at the same electrical potential.

Residual Current Testing

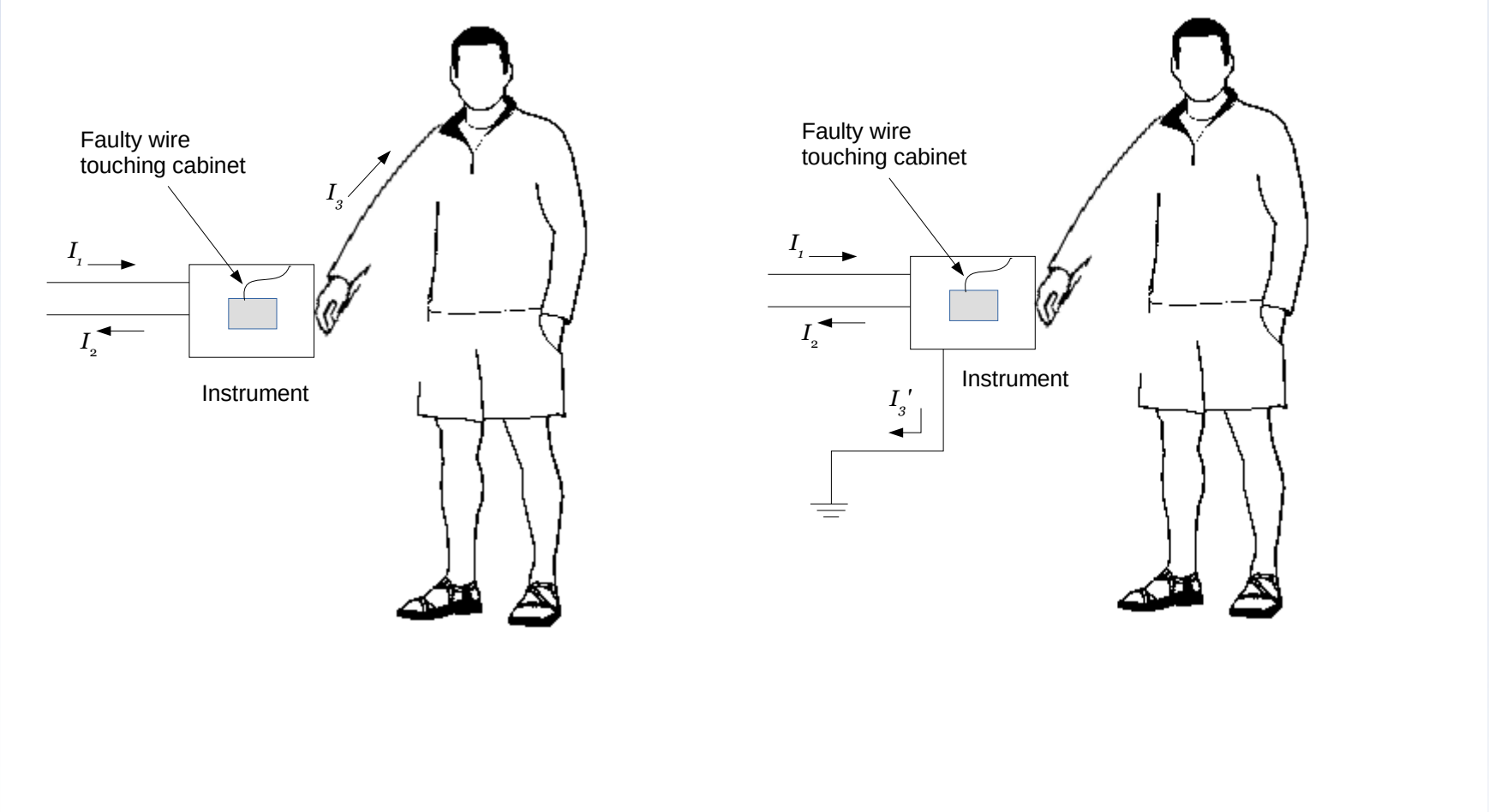


If there is no leakage to ground, $I_1 = I_2$.

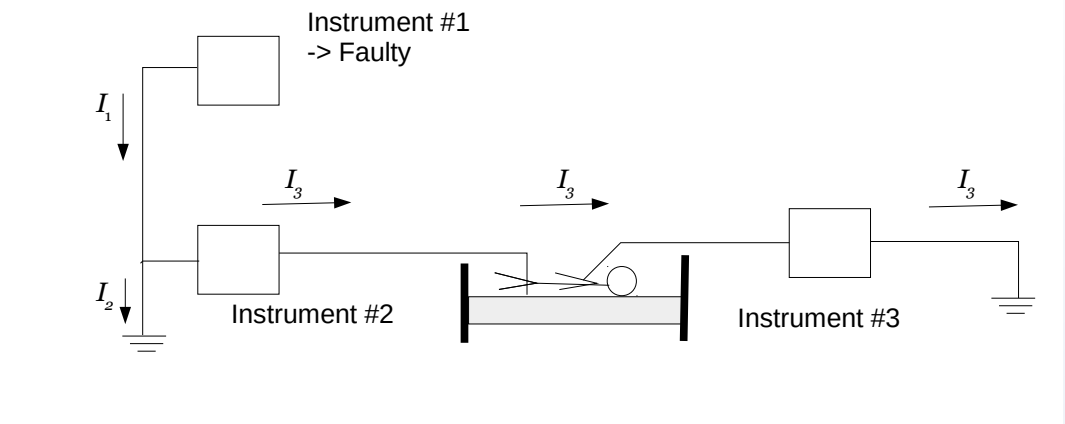
Residual Current Devices can be used to detect ground line leakage, and imbalance in 3-phase circuits (here the neutral may not always be balanced, even without fault- therefore, neutral should also be monitored).

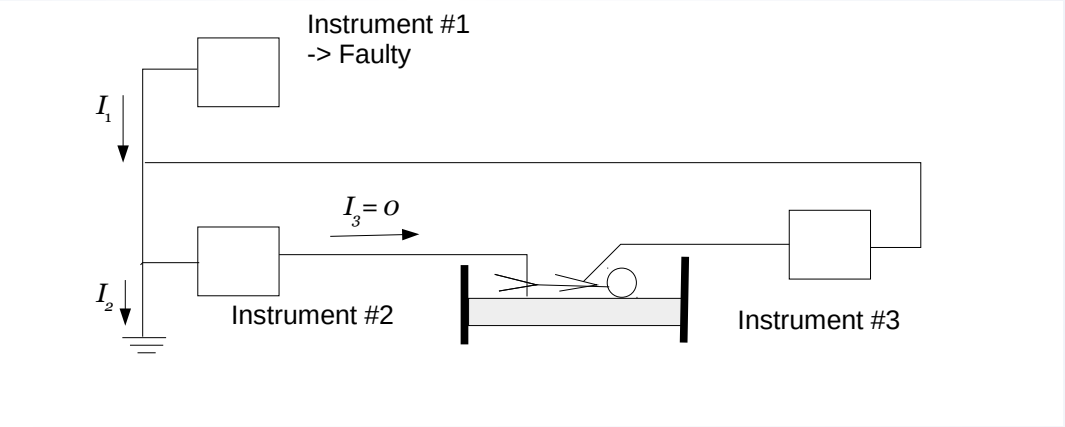
MCB, ELCB, RCCB

Leakage Currents



Danger with Multiple Grounds





Danger to Humans – Kinds of Danger

Rules of Thumb

For electrical current entering from the surface of the skin

Less than 1mA: Microshock
1mA: Threshold of perception
5mA: Maximum harmless current
10mA: Let-go current
100mA: Ventricular fibrillation
5A: Burns

For electrical current directly into the heart (e.g., via a cardiac catheter)
Safe current is about 10μA