



2023 Midwest Healthcare  
Engineering  
CONFERENCE & TRADE SHOW



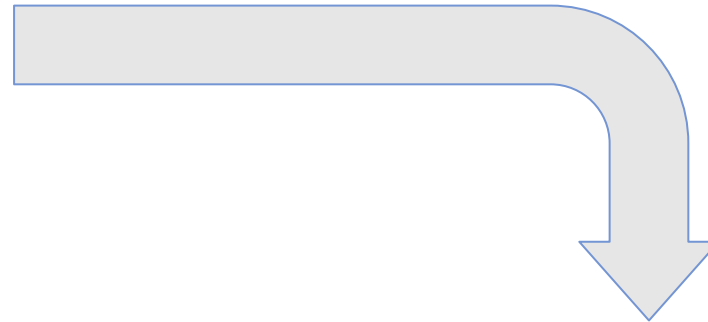
**BRIDGING  
THE GAP**

## Agenda / Objectives

- **Explore why Electrical Safety is Important in Hospitals**
- **Electrical Power Review**
- **Grounded Power System (GPS) vs. Isolated Power System (IPS)**
- **LIM Alarms - What to Do**

- **Several Types of Risk in Healthcare Facilities**

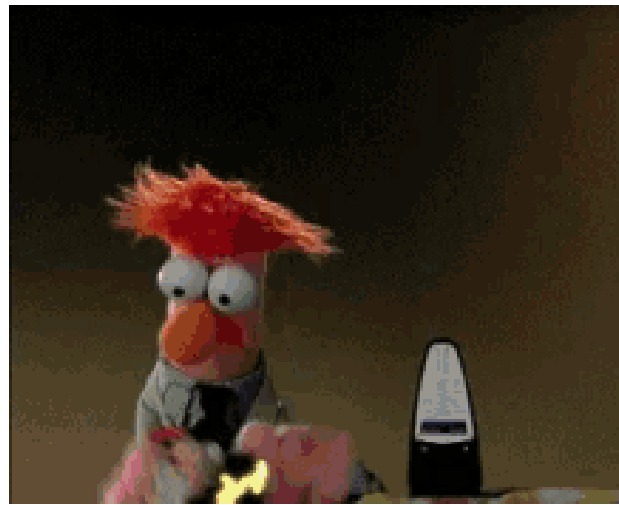
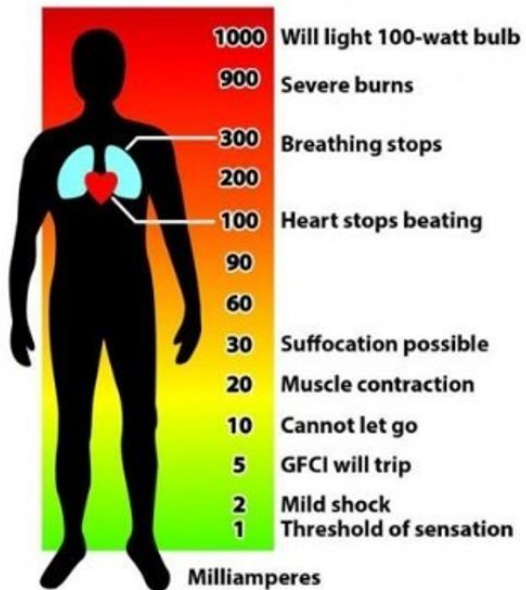
- Electrical-related risks
- Mechanical risk sources
- Chemical risk sources
- Thermal risk sources
- Risk due to ionizing radiation
- Risk due to RF fields
- Biological hazards
- Human failure

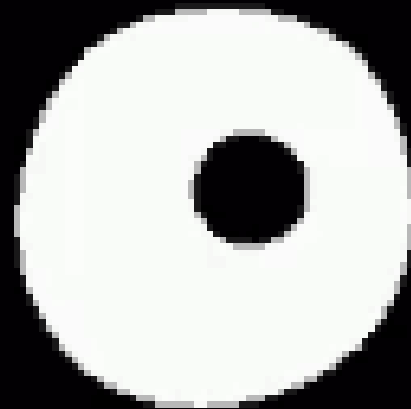


- **Dangerous currents flowing through the body**
- **Interruption of power supply**
- Inadequate quality mains voltage
- Excessive temperatures
- **Arcing**
- **Ignition of explosive mixtures**
- Extraneous influences, cumulative effects

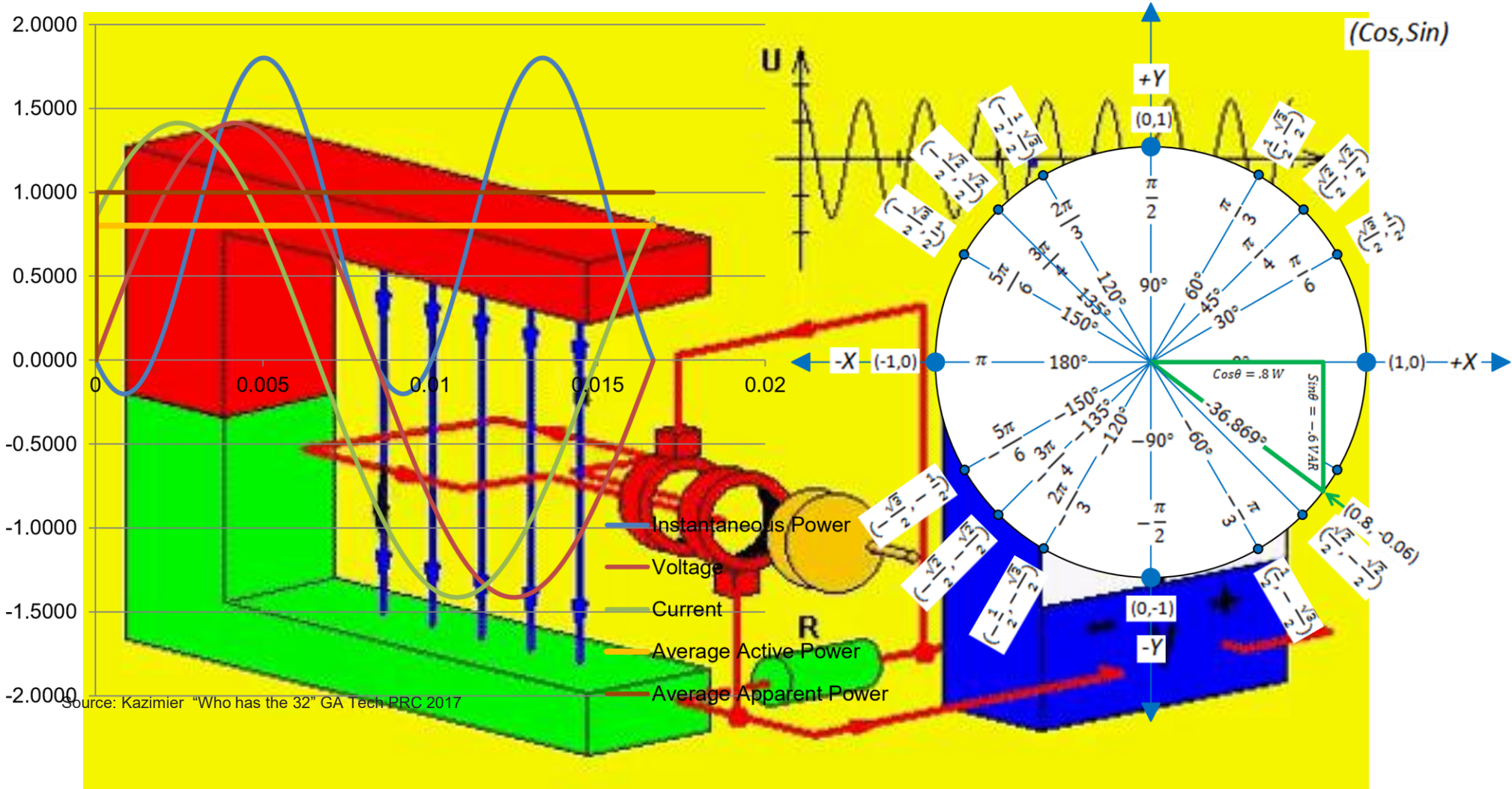
# Electrical Safety in Healthcare Facilities

- Risk of electrical shock:
  - Reduced resistance when skin is wet
  - Patient's natural reactions to shock – reduced or switched off
  - Heart muscle highly sensitive to electric current ( $>10 \mu\text{A} = 0.000010\text{A}$ )
  - Invasive devices bypass the electrical resistance of the skin



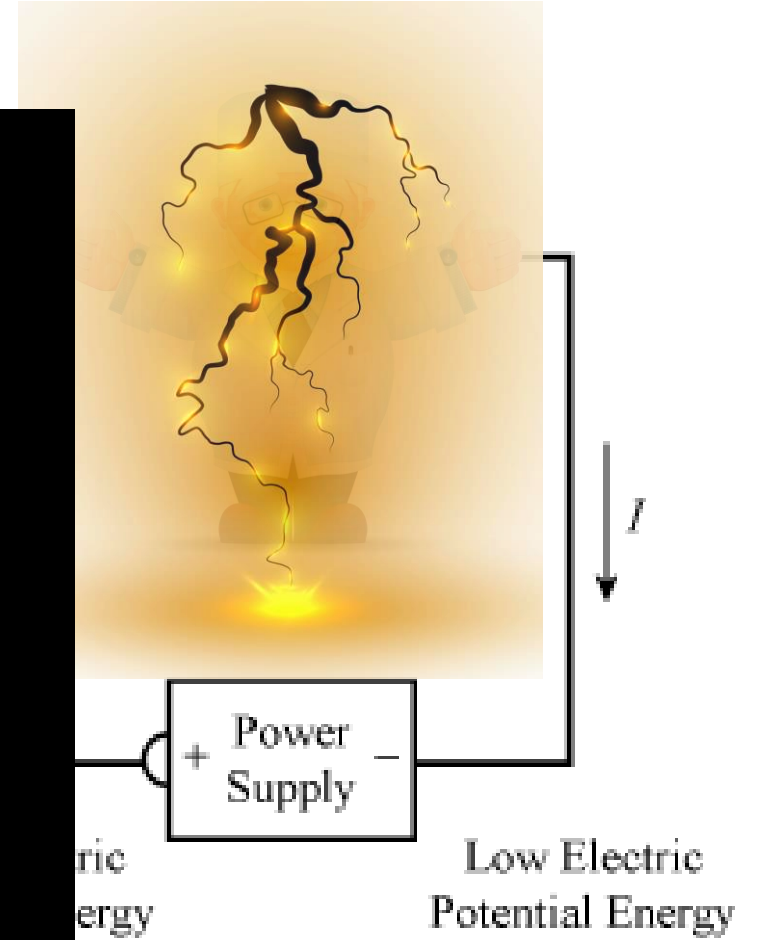


# Electrical Power Review

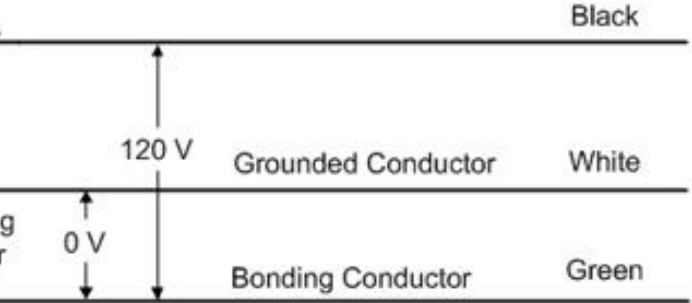


Source: Kazimier "Who has the 32" GA Tech PRC 2017

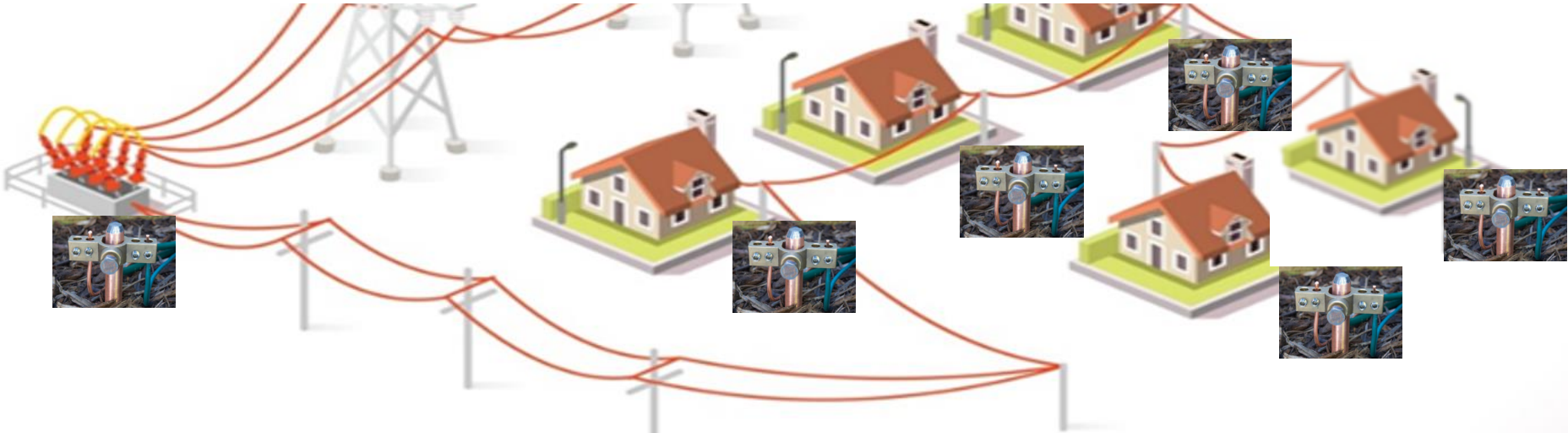
# Electrical Power Review



# Grounded Power System (GPS) vs. Isolated Power System (IPS)

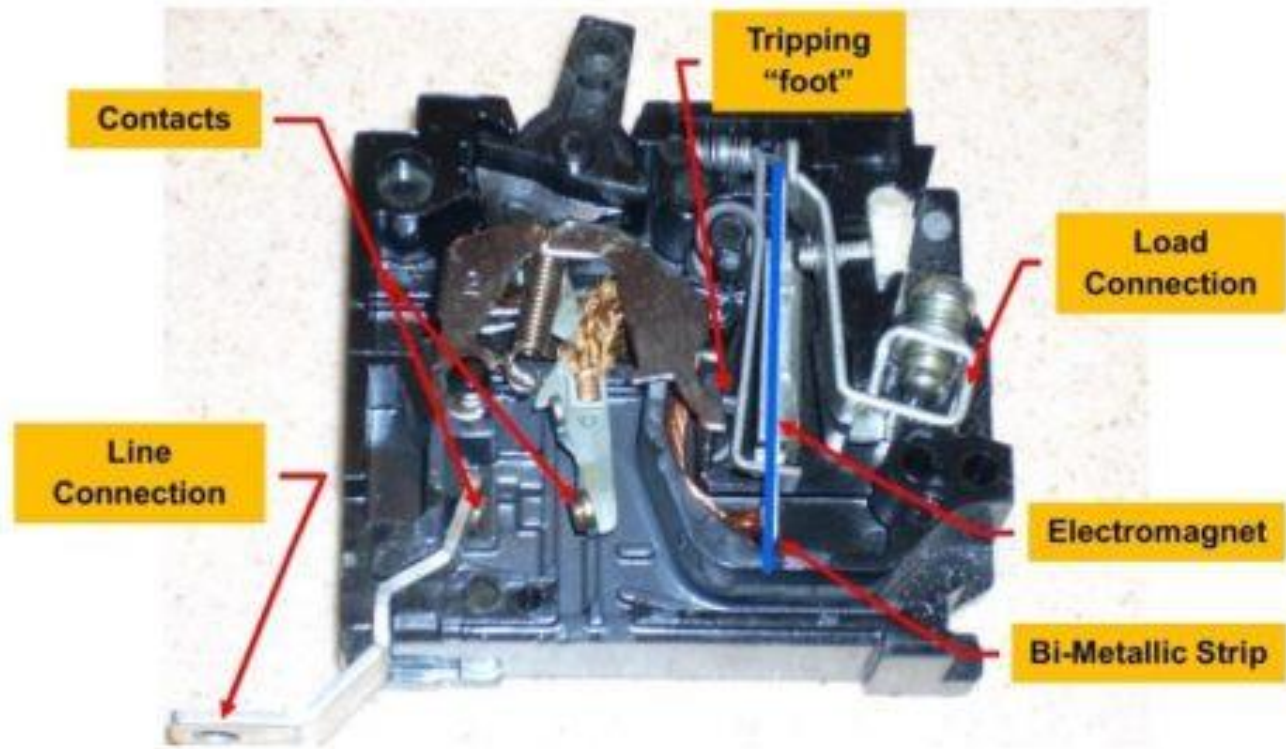


Grounded System





# Grounded Power System (GPS) vs. Isolated Power System (IPS)

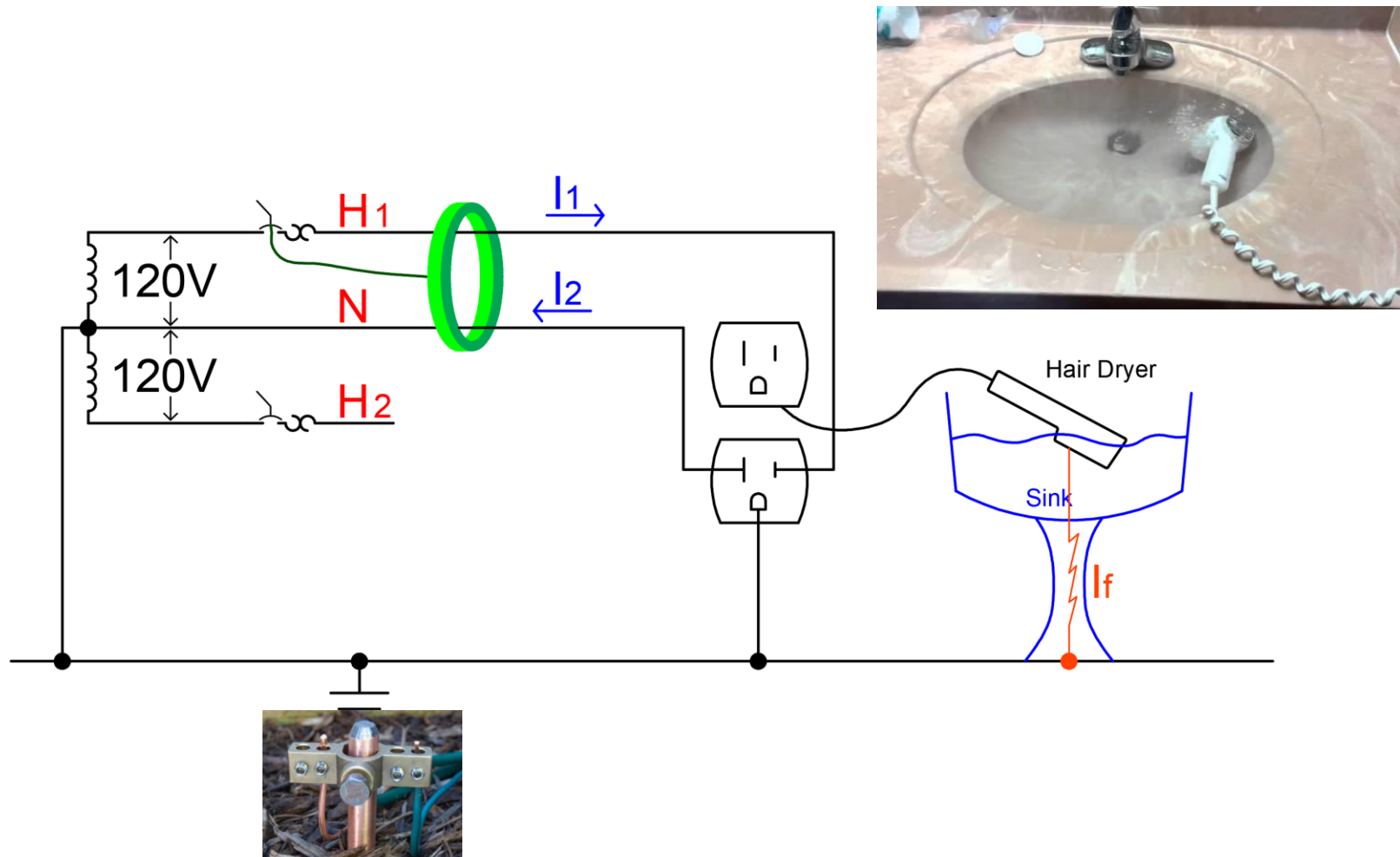


Source: <https://www.rvtravel.com/rv-electricity-everything-wrong-circuit-breakers-rvt-1023/>

## NFPA 99 - Wet Procedure Locations

- **The entire operating room shall be considered to be a wet procedure location**, unless a risk assessment conducted by the health care governing body determines otherwise.
  - Risk assessment should include all relevant parties
    - Clinicians, biomedical engineering staff, and facility safety engineering staff
- Wet Procedure Locations NFPA 99 – 2018 6.3.2.3.4
  - Area in a patient care room where a procedure is performed
  - Normally subject to wet conditions while patients are present
  - Including **standing fluids** on the floor **or drenching** of the work area,  
either of which condition is intimate to the patient or staff
- Wet procedure locations shall be provided with special protection against electric shock.
  - **Isolated Power System or Class A GFCI Receptacles** (6.3.2.3.2)
    - **GFCI only if loss of power can be tolerated ... “Risk assessment should be conducted”**

# Grounded Power System (GPS) vs. Isolated Power System (IPS)



# Grounded Power System (GPS) vs. Isolated Power System (IPS)

16

For complete listing of Hubbell Wiring and Premise products see our full line catalogs. [www.hubbell-wiring.com](http://www.hubbell-wiring.com)

With a restroom in every patient room and throughout staff and public areas, hospitals and healthcare facilities can contain hundreds of restrooms. Required by code, receptacles in any wet area must be a ground fault circuit interrupter. Many healthcare restrooms require hospital grade GFCIs while others can use commercial-grade GFCIs.

### Hospital Grade GFCI Tamper-Resistant Weather Resistant Receptacles

- Ground fault indicator flashes red when device has lost capability to provide protection
- Test button functionally tests both electronic components and trip mechanism
- No power at device face if reverse wired



	AUTOGUARD® Self Test	Circuit Guard®	SNAPConnect® GFCI*	Circuit Guard®
15A 125V	Ivory Red White	GFR8200HTR GFR8200HRTR GFR8200HWTR	GFR8200SNAPINA GFR8200SNAPRNA GFR8200SNAPWNA	GFR8200HILA GFR8200HRLA GFR8200HWLA
20A 125V	Ivory Red White	GFR8300HTR GFR8300HRTR GFR8300HWTR	GFR8300SNAPINA GFR8300SNAPRNA GFR8300SNAPWNA	GFR8300HILA GFR8300HRLA GFR8300HWLA

Description	Wire Type	General Use	Assembled in USA
SNAPConnect® Right Angle Pigtailed Connector - 600V Clear right angle terminal with 6 inch leads #12 AWG THHN/THWN-2; Polycarbonate housing material SNAPConnect GFCI must use a SNAPConnect Pigtailed connector.	Solid Stranded	SNAP1RA SNAP2RA	SNAP1RNA SNAP2RNA

### Ultrasonic Adaptive Technology Occupancy Sensors

- Provides superior motion sensitivity, even in stalls
- Automatically adjusts sensor settings for optimum performance
- Use optional isolated relay to integrate with building automation and HVAC systems



Ceiling Sensor	Color	Catalog No.	Wall Switch	Color	Catalog No.
Description			Description		



**GFCI Safety Code**  
 The combination of GFCI protection and tamper-resistant safety provides an ideal "one-stop" Hubbell solution. Hubbell tamper-resistant GFCI devices also include a weather resistant rating per NEC® 406.9, providing UV and corrosion resistance for harsh, damp applications.

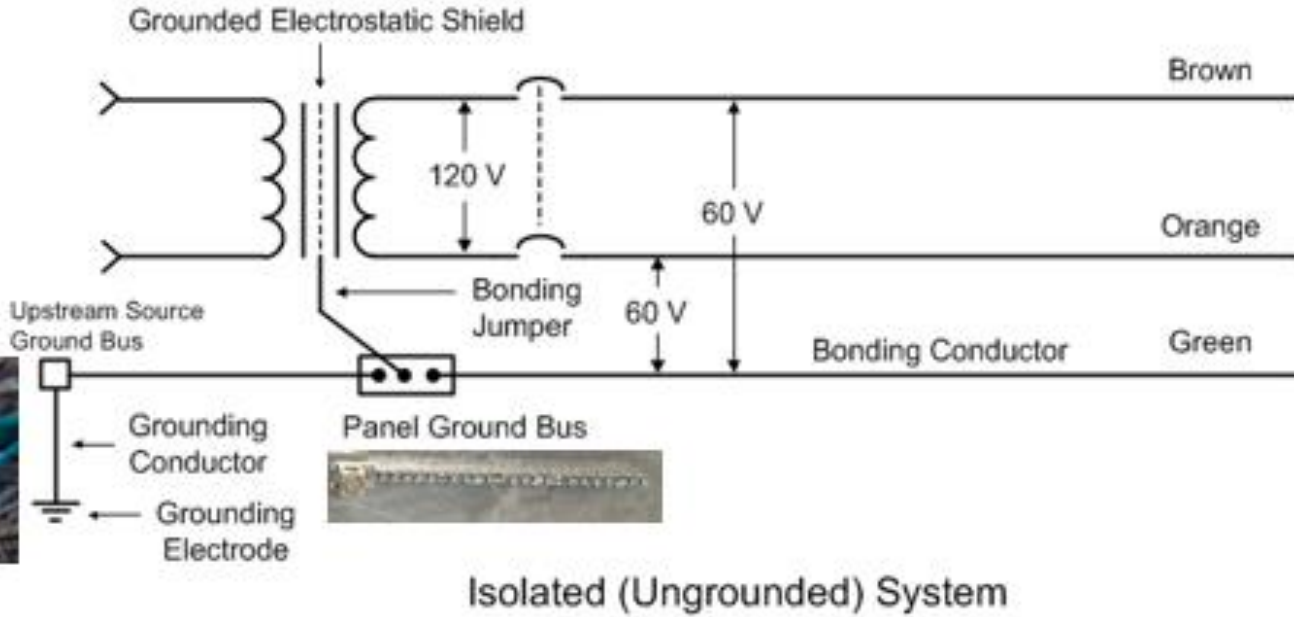
While GFCIs protect people in bathrooms, scrub rooms, kitchenettes and other potentially wet locations throughout healthcare facilities, they should not be used in critical care patient areas or for electrical life support equipment in ICUs and operating rooms because of the possibility of power interruption.

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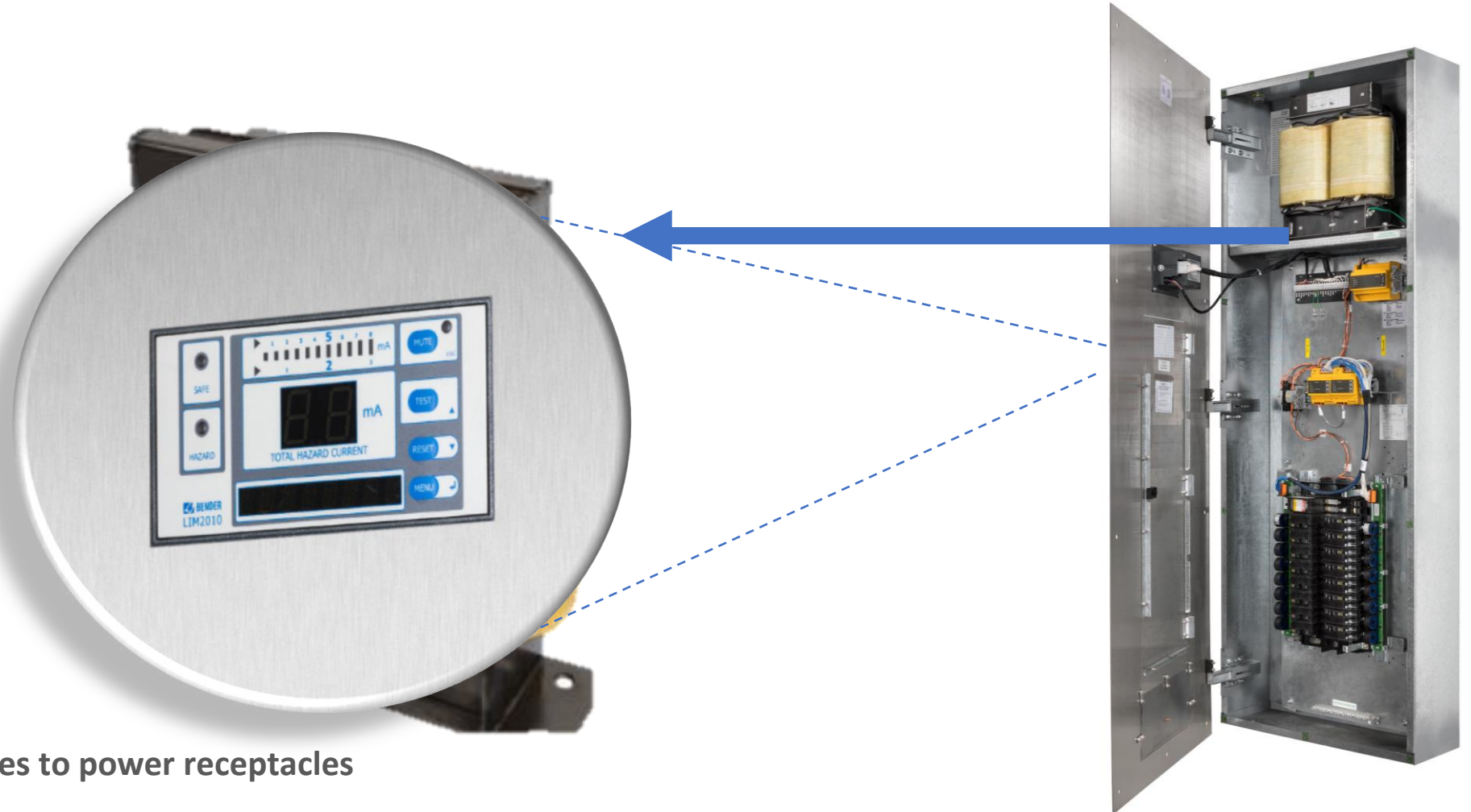
# Grounded Power System (GPS) vs. Isolated Power System (IPS)

- In order to be competitive, GFCIs are usually low-cost devices.
  - There are examples of **failed GFCIs** that **do not open** under fault conditions.
- Per NEC Article 110, GFCIs should be tested monthly because the manufacturer's state, "test monthly."
  - Reality: **GFCIs are rarely tested** and overlooked during routine maintenance.
- Isolated power is more likely to be maintained and tested.
- Isolated power provides **audible** and visual warnings when fault conditions exist.
  - A single ground fault condition is typically not dangerous and does NOT result in a loss of power.

# Grounded Power System (GPS) vs. Isolated Power System (IPS)



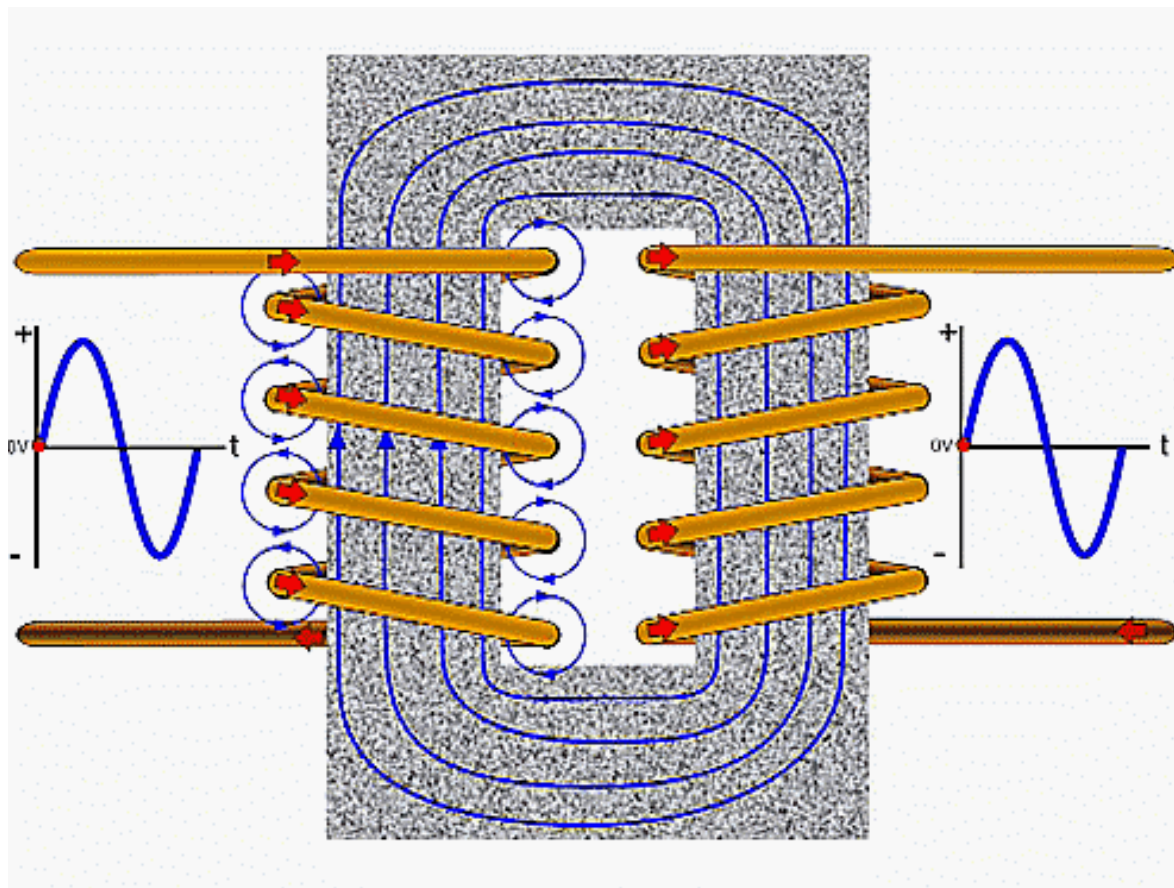
# Grounded Power System (GPS) vs. Isolated Power System (IPS)



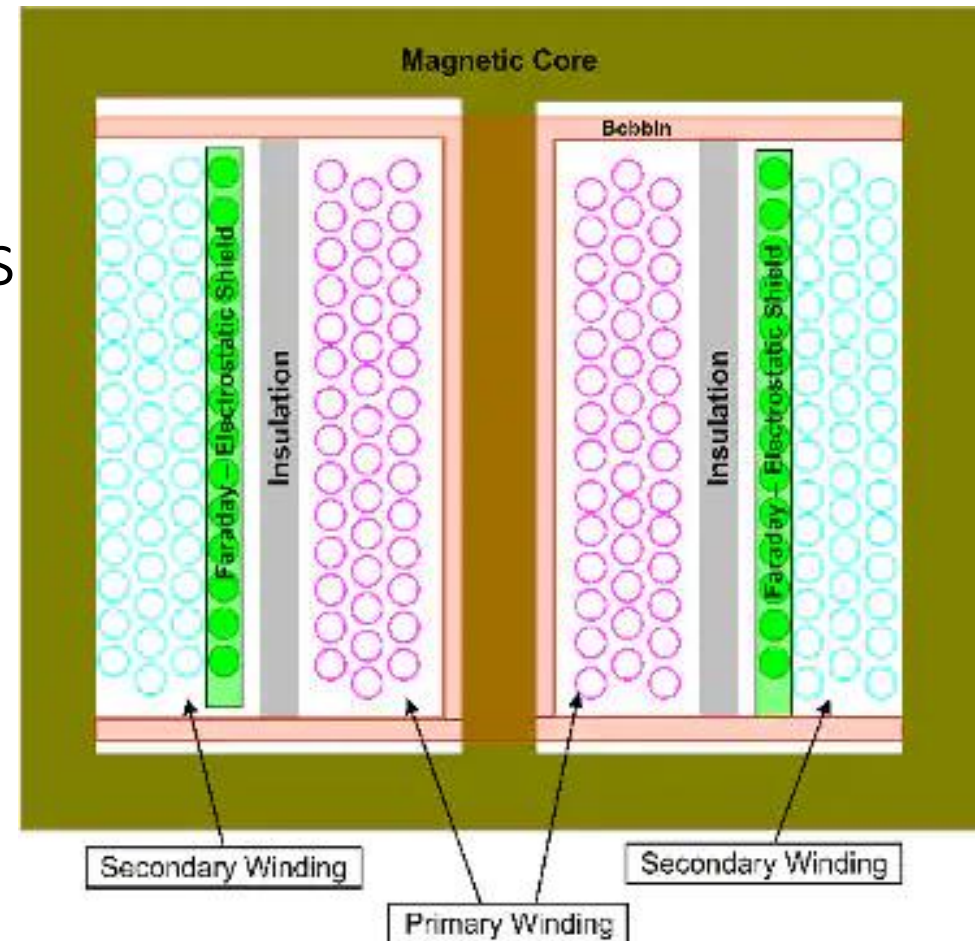
## Isolated Power Panel

1. Transformer
2. Line Isolation Monitor
3. Breakers and accessories to power receptacles

Source: [Isolation Transformers Provide Galvanic Isolation | DigiKey](#)



$I_s$





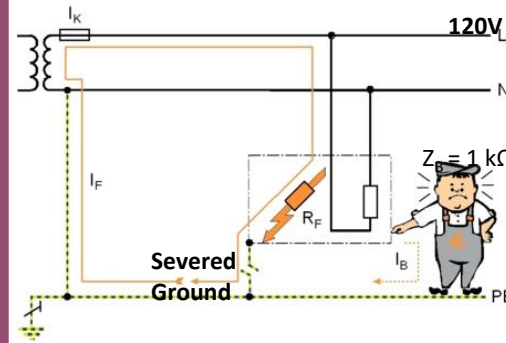
# Grounded Power System (GPS) vs. Isolated Power System (IPS)

## Fault Current

- The fault current is only limited by the body's impedance ( $1k\Omega$ )
- Could be lethal

$$I_B = \frac{\text{Supply Voltage}}{\text{Impedance of body}} \rightarrow \frac{120V}{(1k\Omega)} = \mathbf{120mA}$$

## Grounded System

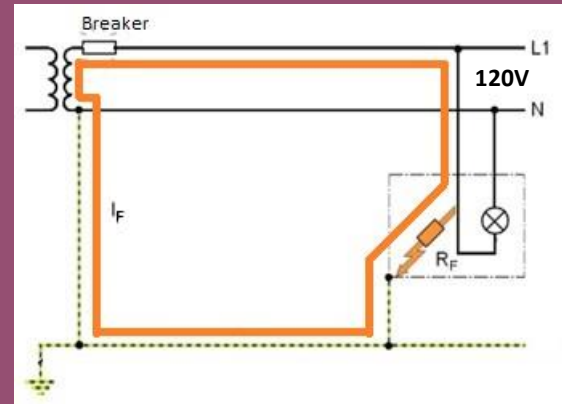


# Grounded Power System (GPS) vs. Isolated Power System (IPS)

## Fault

- Fault current flows through medical device and through ground back to the transformer
  - Overcurrent Protection Device could trip
  - Risk of destroying equipment
  - GFCI could trip resulting in unexpected interruption of power

## Grounded System



# Grounded Power System (GPS) vs. Isolated Power System (IPS)

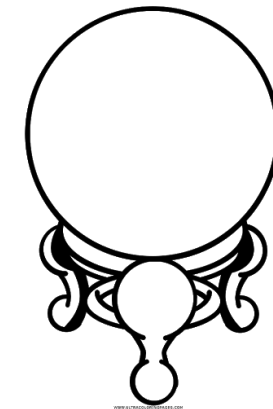
1939

- Walther Hans Bender developed an insulation monitoring device that protected men and machines against the hazards of electrical faults at the same time ensuring an uninterruptible power supply

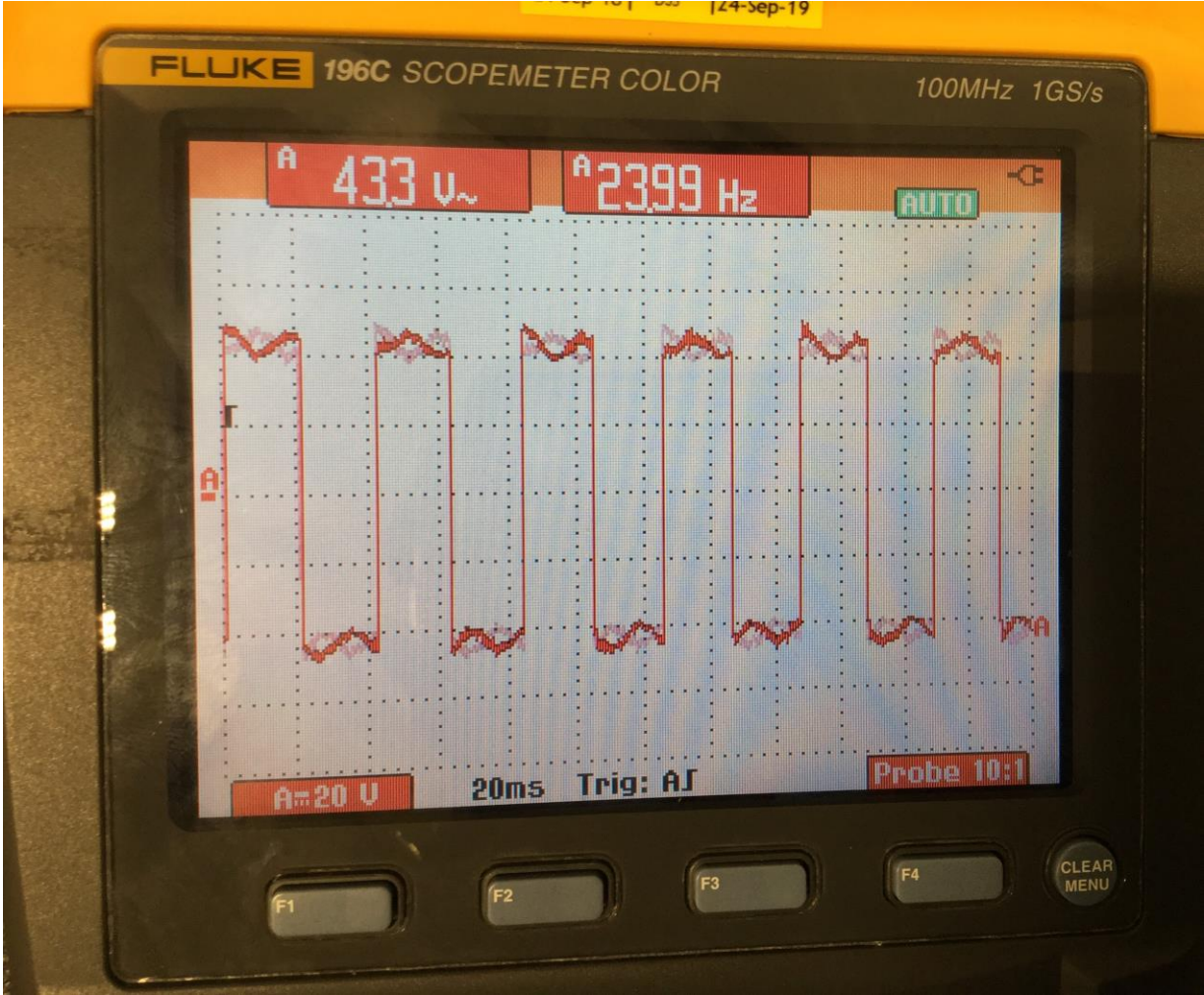


# Grounded Power System (GPS) vs. Isolated Power System (IPS)

- Line Isolation Monitor (LIM)
  - Test instrument designed to measure how “isolated” the system is from ground by continually measuring impedance to ground of each phase.
  - **Predicts** and displays what the highest ground fault current **would be** if the line with the highest impedance would become connected to ground.

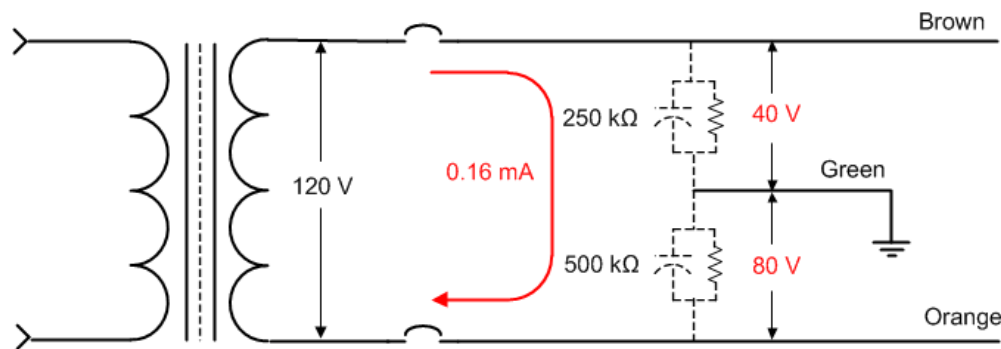


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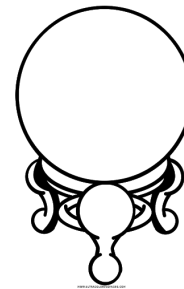


# Grounded Power System (GPS) vs. Isolated Power System (IPS)

- Line Isolation Monitor (LIM)
  - **Predicts** and displays what the highest ground fault current **would be** if the line with the highest impedance would be connected to ground.
- This predicted current is called the Total Hazard Current (THC)

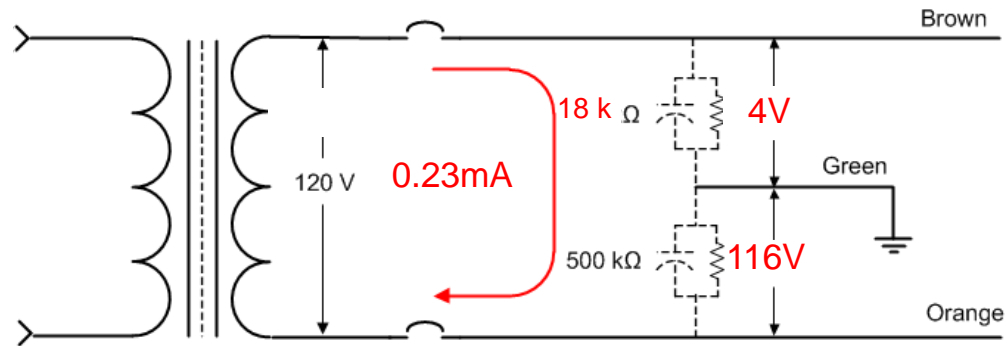


$$\text{THC} = \frac{120\text{V}}{250\text{k}\Omega} = 0.48 \text{ mA}$$

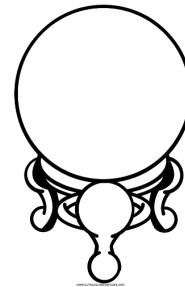


# Grounded Power System (GPS) vs. Isolated Power System (IPS)

- Example of a [low impedance] ground fault:
- Total Hazard Current alarm point 5 mA (NFPA 99 & NEC)



$$\text{THC} = \frac{120\text{V}}{18\text{k}\Omega} = 6.8 \text{ mA}$$



- Do **NOT** endanger the patient by discontinuing the procedure prematurely
  - The alarm does not usually mean there is imminent danger
- Acknowledge the alarm and immediately notify personnel responsible for the equipment's maintenance
- Situational awareness:
  - if the alarm happens soon after a piece of electrical equipment is connected, disconnect the equipment that was most recently connected.
    - Only disconnect the equipment if it will not endanger the patient.
  - Did something change like a cart running over a cord or a cord accidentally moved, pulled on etc?
  - Has a piece of electrical equipment started to malfunction?
  - Check the medical devices in the room for proper working order and monitor important devices during the remainder of the procedure.
- Once the procedure is complete, responsible personnel should investigate & correct the alarm's root cause.
  - This process is often tedious and time consuming (if done manually) and requires de-energizing the circuits on the system.
  - Automatic on-line fault location systems are available in the marketplace.



# Thank You!

Come to Booth 105 for Q&A or Further  
Discussion