Final Written Examination

5/1/2015

Time all: 3 Hrs

Answer the following questions

Question One: Choose the best answer: ***(YOU CAN SELECT MORE THAN ONE ANSWER)***

[10 Marks]

1) ***The LIM (line isolation monitor)***
   - ***a)*** Measures leakage current flowing from the electrical equipment to the patient
   - ***b)*** Sounds an alarm if the leakage current exceeds 50 mA
   - ***c)*** Measures the impedance between AC wiring and ground
   - ***d)*** Cuts off power to the circuit if a faulty piece of equipment is connected

2) ***Operating rooms use an isolated power supply because:***
   - ***a)*** Grounding cannot occur
   - ***b)*** Contact with both wires of the isolation transformer would cause no shock
   - ***c)*** Leakage current is zero
   - ***d)*** It affords protection against high amperage electrocution

3) ***Low voltage = Low hazard***
   - ***a)*** True
   - ***b)*** False

4) ***If a friend receives a severe electric shock from an electrical appliance in your home, what should your first response be?***
   - ***a)*** Take the appliance and heave it aside so that you can tend to your friend.
   - ***b)*** Run to the circuit breaker and turn off the main switch.
   - ***c)*** Use a wooden broomstick to push the appliance away safely.

5) ***Which of the following situations is NOT a fault condition***
   - ***a)*** external voltage on the applied part
   - ***b)*** ingress of gas or fluid
   - ***c)*** mains polarity reversed
   - ***d)*** patient accidentally touching earth

Question Two: **[12 Marks]**

1. How can leakage current are reduced by good: a) Instrument design. b) Clinical conditions.

Leakage current reduction via instrument design:
Through proper layout and insulation to minimize the capacitance between all hot conductors and the chassis

Leakage current reduction via clinical conditions (power distribution):

- Equipotential grounding system.
- Isolated power-distribution system (line isolation transformer with line isolation monitor).
- Ground-fault circuit interrupters (GFCI)

2. What is meant by susceptibility parameters? (mention three of them) And what is the purpose of the earth wire connection in 3-point plugs?

Parameters that changes the physiological effect of the current on patients like:

1) Frequency.
2) Duration.
3) Weight.
4) Points of entry.

The purpose of the earth wire is to make a path for leakage current and fault current.

3. What happens if you personally complete a circuit between the following leads:

a) Hot – Hot

b) Hot – Neutral

c) Hot – Ground

d) Neutral – Ground

From the power company the electricity is distributed as Hot, Neutral and ground wires.

Circuit completed personally	**Effect**
1) Hot – Hot	No effect
2) Hot – Neutral	**Shock hazard**
3) Hot – Ground	Shock hazard
4) Neutral - Ground	No effect

4. If one line from the isolation transformer shorts one chassis, and the other line from the isolation transformer shorts to another chassis, and both have broken ground wires, will the line isolation monitor indicate a fault?

5. List the items for protection the patient through **Equipment Design**

1. Reliable grounding for equipment

   Strain-relief devices for cords, where cord enters the equipment and between the cord and plug

2. Reduction of leakage current

   Through proper layout and insulation to minimize the capacitance between all hot conductors and the chassis

3. Double insulated equipment

   prevent the contact of the patient with the chassis or any other conducting surface (outer case being insulating material, plastic knobs, etc.)

4. Operation at low voltage

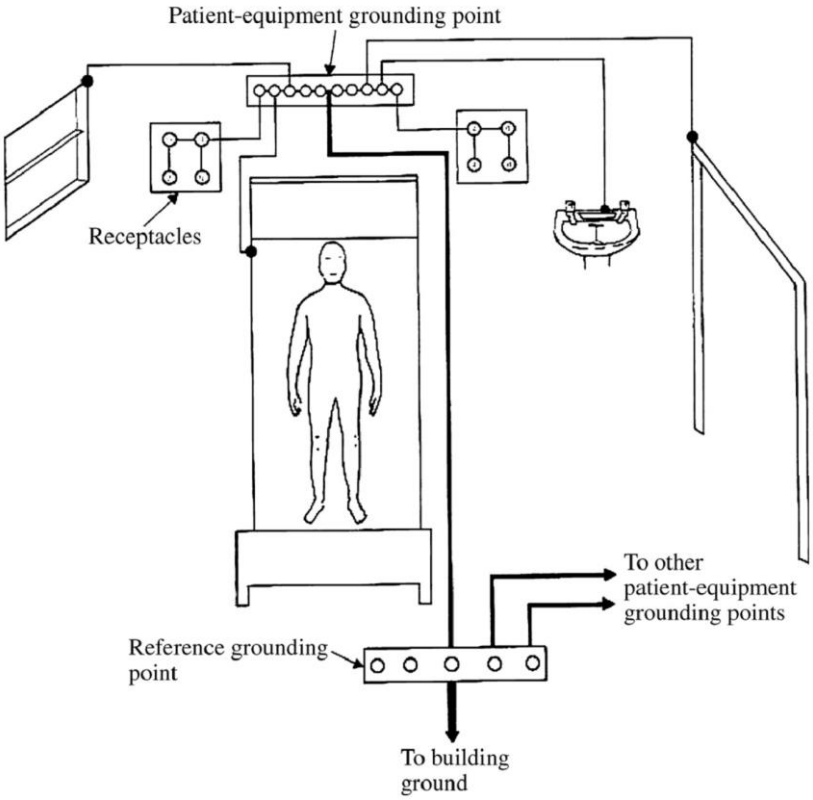
   Solid state devices operating at <10V are far less likely to cause macroshock

5. Electrical isolation

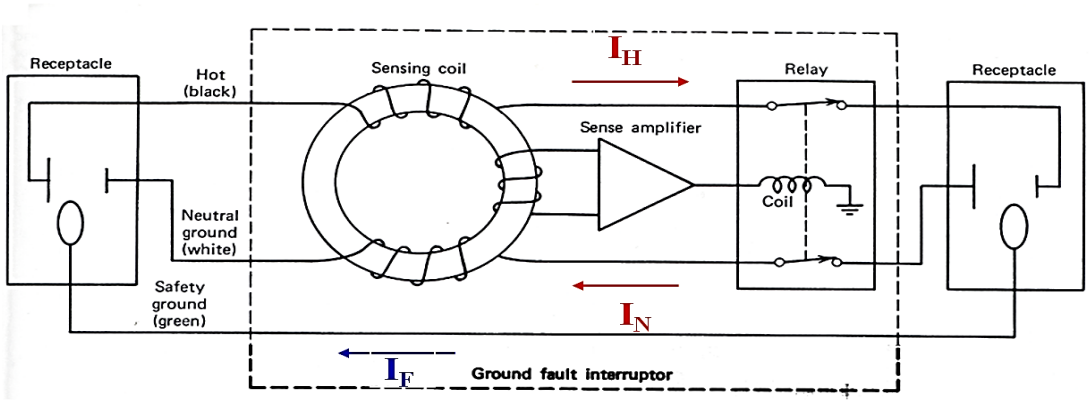
   Electrical isolation in Equipment , circuit designs & Heart connection

Question Three: **mention everything in the drawing** **[12 Marks]**

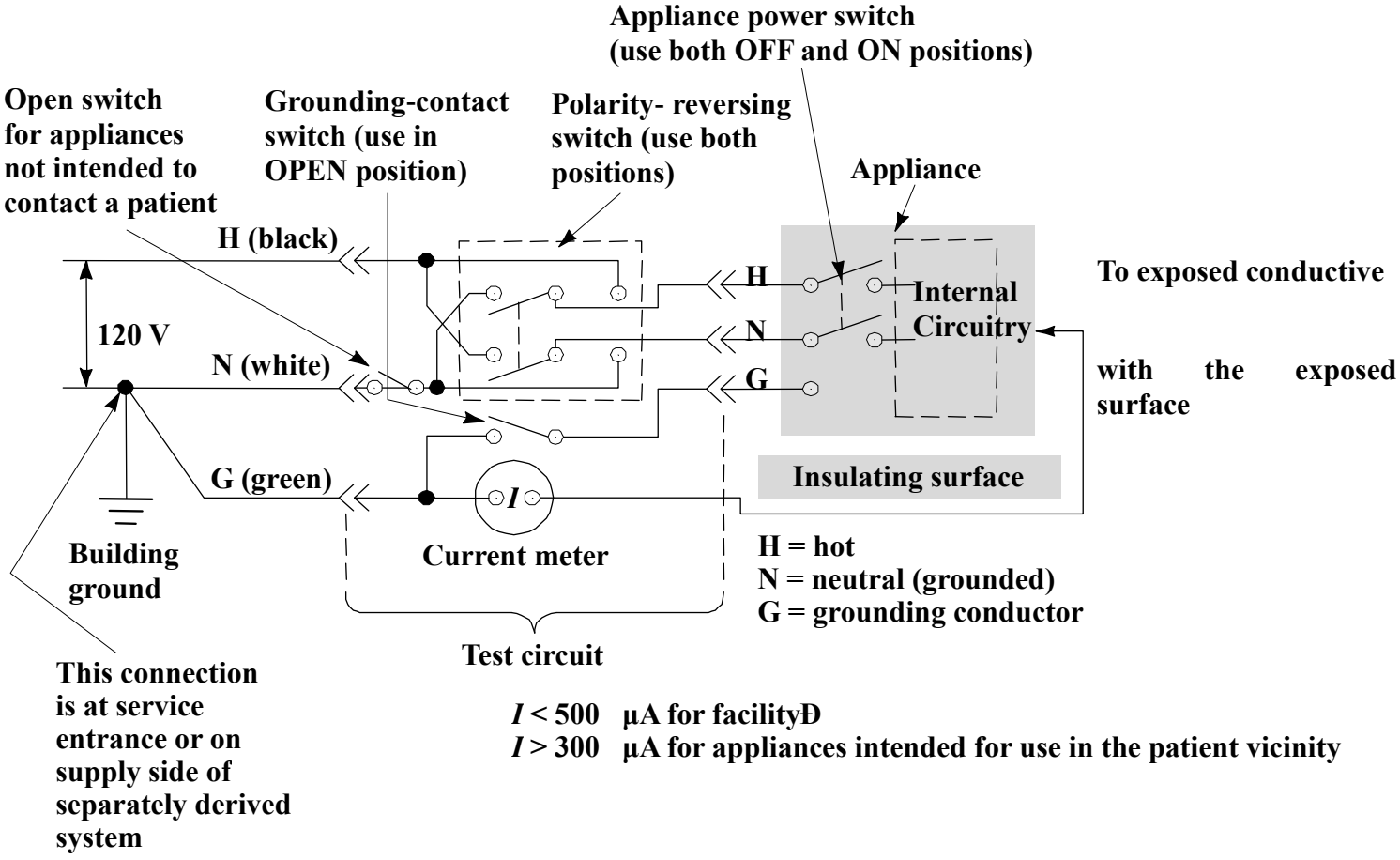
1. Equipotential grounding system.



2. Ground fault interrupter circuit.

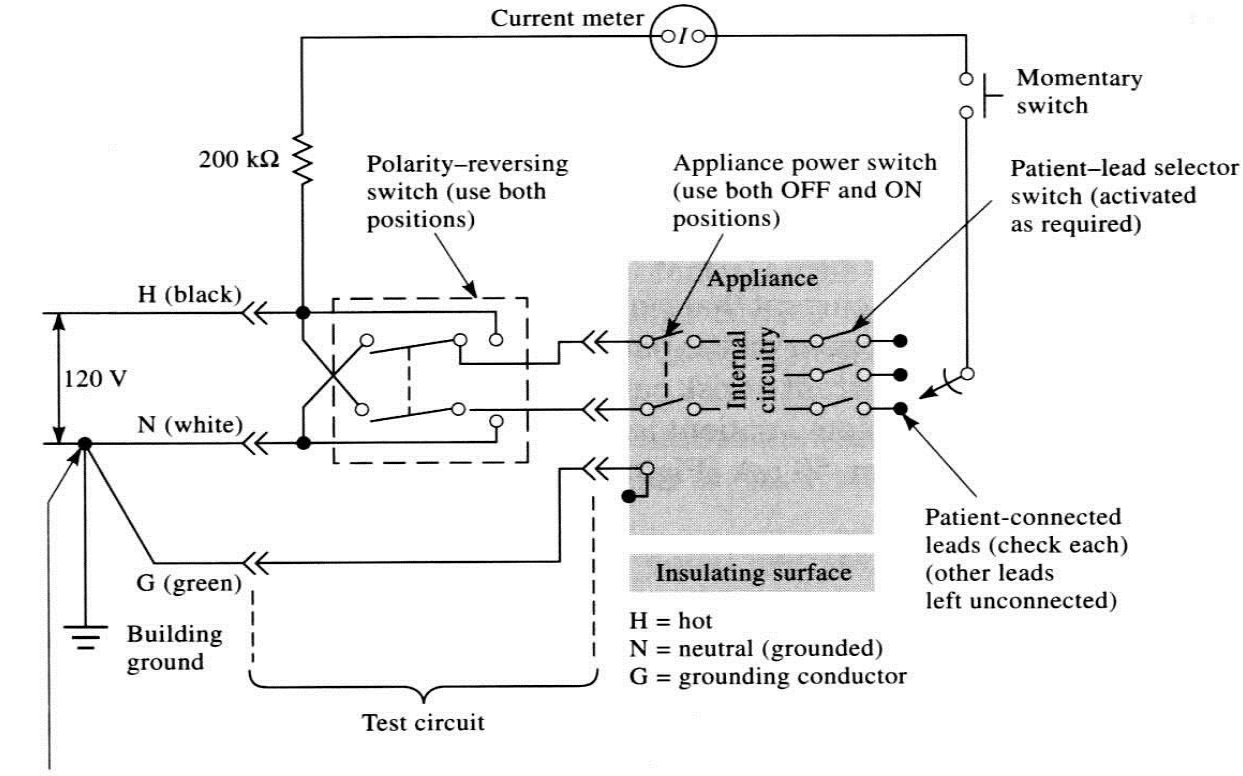


3. Test for chassis leakage current.



$I < 500$ µA for facilityÐ
$I > 300$ µA for appliances intended for use in the patient vicinity

4. Test for ac isolation current



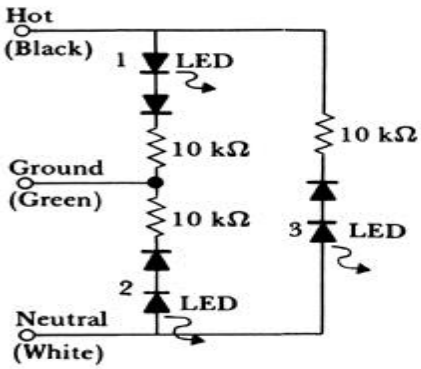
Question Four: **[13 Marks]**

1. Design with drawing a complete power and grounding systems for

a) **ICU** that consists of many instruments such as (ECG, EEG, Defibrillator & Saline-filled catheter) using isolation power system & equipotential grounding system

b) Swimming pool. using GFCI & equipotential grounding system

2. Design a tester for an electric receptacle that will indicate as many states as possible, including those not detected by the common three-LED receptacle testers



Wiring Codes (* ≡ LED on)

	1	2	3
1. Hot open (or all hot!)	○	○	○
2. Neutral open	*	○	○
3. No possible wiring	○	*	○
4. Ground open	○	○	*
5. Hot/ground reversed	*	*	○
6. Correct (or ground/neutral reversed)	*	○	*
7. Hot/neutral reversed	○	*	*
8. Hot open and neutral/hot	*	*	*

3. Describe with drawing the ground isolated input (ECG) preamplifier

- **Ground isolated input (ECG) preamplifier**

➢ The isolated patient circuit are achieved by providing an isolation transformer in the signal path in the AC power circuit

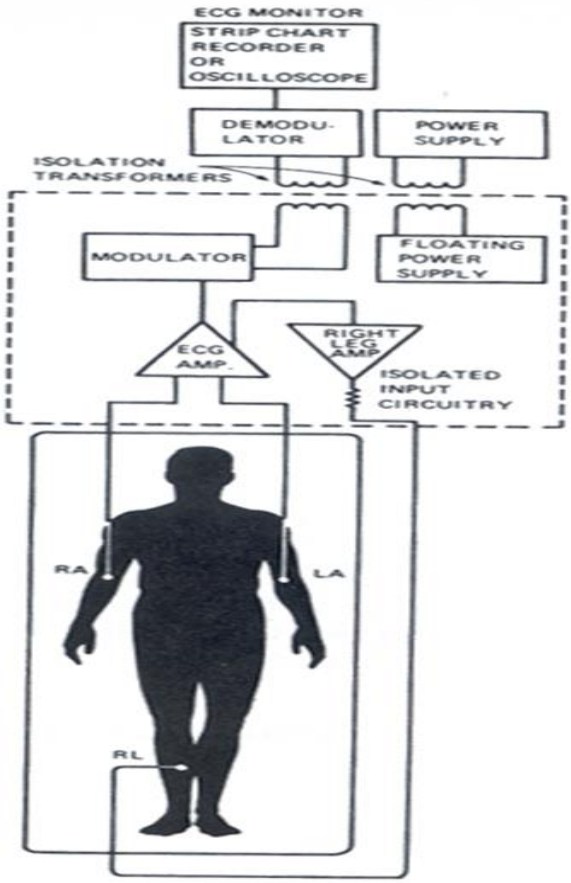
➢ **Advantages :**

1- isolate the patient from ground and other portion of the equipment

2- isolation impedance over 10 M ohm between input terminals and ground

➢ **Disadvantages:**

1- very high cost



Question Five: **[13 Marks]**

1.

Describe the situation in Fig.1with all hazard and reasons for it

The situation is micro shock

Hazards : 1. Short circuit from vacuum cleaner will pass return current to the patient and micro shock occur

2. Different ground will appear voltage on patient and pass current through patient

Reasons: from vacuum cleaner and from the isolated grounding for two instrument

Draw the new suitable situation with safe connection to avoid all hazards.

-Not connect any clean device in the same receptacles of patient equipment

-Connect all patient equipment to reference ground in the room and then to central ground point

Draw this item

2. If the patient is being monitored by an ground isolated input ECG monitor that grounds the right leg electrode and the patient's arterial pressure is being monitored using an intracardiac saline filled catheter connected to a pressure transducer, which attaches to the pressure monitor case and then to ground. These monitors are connected to separate; grounded three-wire wall receptacles. The grounds from these two outlets are not connected together except at a central power distribution panel. The patient heart also connected to an external grounded pacemaker via catheter. Let us assume that a cleaning service person now plugs a vacuum cleaner into a wall outlet on the same circuit as the saline filled catheter monitor. The cleaner has a three-wire power cord with a third broken grounding wire. The windings of the motor are continually exposed to dust, often damp, which provides a good path for an eventual "winding-to-outer-case" short, assume the short circuit current is about 1 A ,and the grounding resistance of 0.1 Ω .If the patient's resistance as 500 Ω and the differential voltage between the saline filled and patient ground is 10 mV. Draw the situation and find the current flowing through the patient. Is the patient in danger???

- Because we use ground isolated input ECG monitor the this ground of patient is isolated
- The patient is also grounded by ground of external pacemaker
- Situation is micro shock
- Current pass to the patient is from current by short circuit of vacuum cleaner
- Current = (100mv+10mv)/500 Ω=220uA micro shock hazard