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Department of Biomedical Engineering

Vision Tit 2 Vision Title 3

Course Name: 19BMT204 Biomedical Instrumentation

II Year : IV Semester

Unit V – Patient Safety

Topic : Protection equipment design and Isolation Power system

Protection through Equipment Design

- Strain-relief devices for cords, where cord enters the equipment and between the cord and plug
- Reduction of leakage current through proper layout and insulation to minimize the capacitance between all hot conductors and the chassis
- Double insulation to prevent the contact of the patient with the chassis or any other conducting surface (outer case being insulating material, plastic knobs, etc.)
- Operation at low voltages; solid state devices operating at <10V are far less likely to cause macroshocks

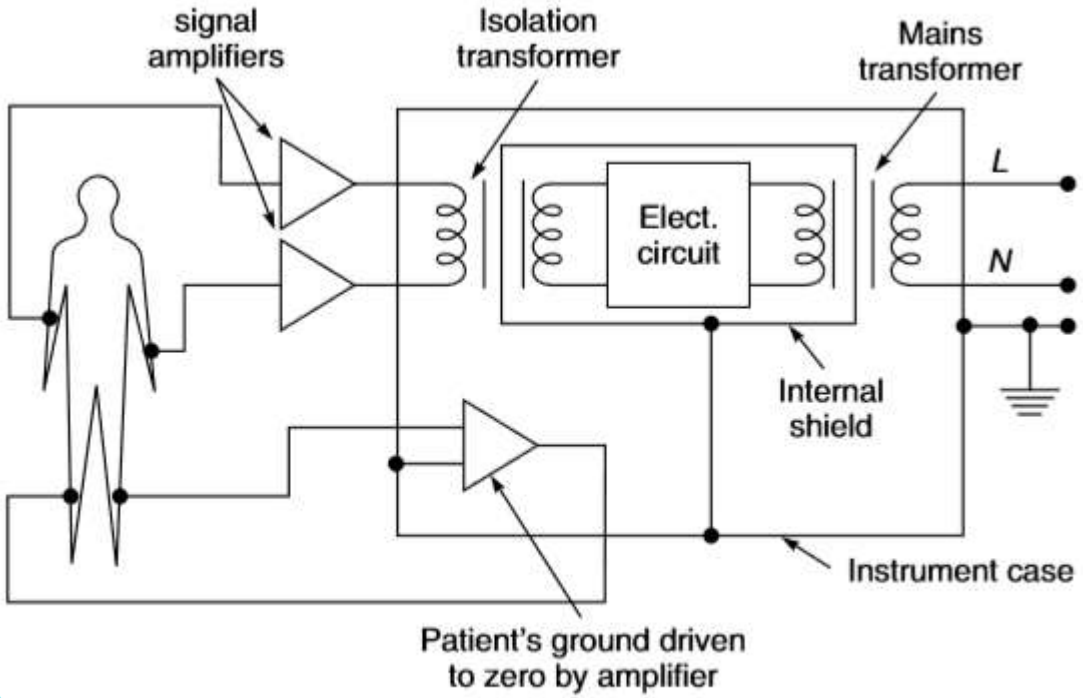
Electrical isolation in circuit design

Isolation Amplifier

- Isolation amplifiers are commonly used for providing protection against leakage currents.
- They break the ohmic continuity of electric signals between the input and output of the amplifier.
- The isolation includes different supply voltage sources and different grounds on each side of the isolation barrier.
- Three methods are used in the design of isolation amplifiers:
  (i) transformer isolation
  (ii) optical isolation
  (iii) capacitive isolation.

Transformer isolation

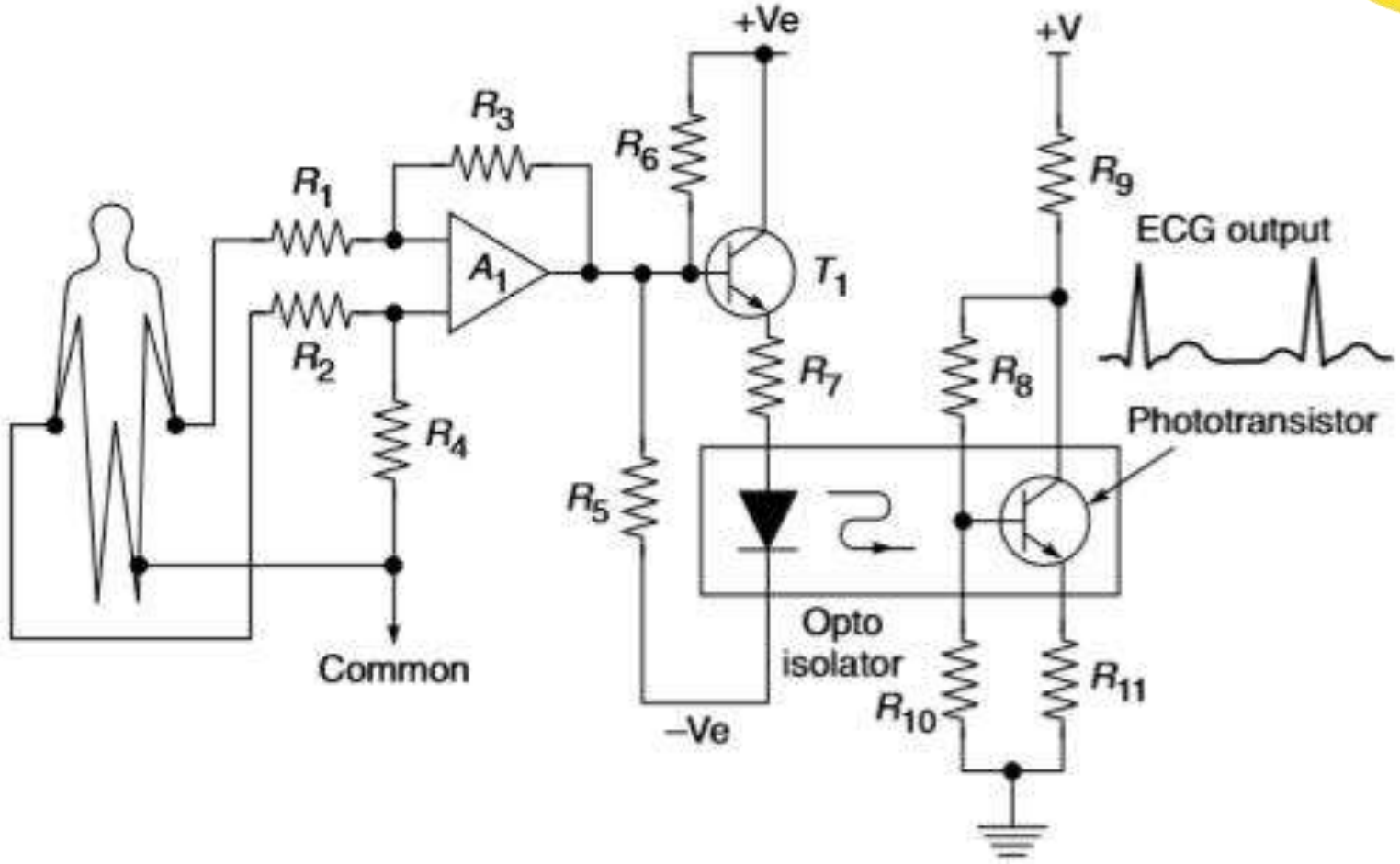
- The transformer uses either a frequency-modulated or a pulsewidth modulated carrier signal with small signal bandwidths up to 30 kHz to carry the signal.
- It uses an internal dc–to-dc converter comprising of a 20 kHz oscillator, transformer, rectifier and filter to supply isolated power.



➤ **Fig. 4.8** *Isolation amplifier (transformer type)*

Optical Isolation

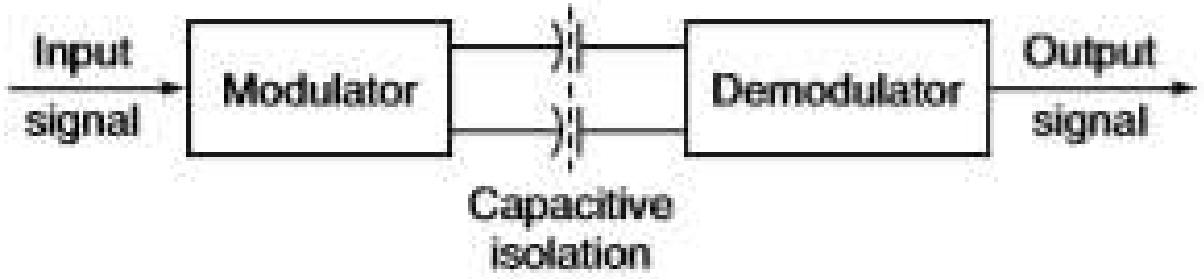
- Isolation achieved by optical means in which the patient is electrically connected with neither the hospital line nor the ground line.
- A separate battery operated circuit supplies power to the patient circuit and the signal of interest is converted into light by a light source (LED).
- This light falls on a phototransistor on the output side, which converts the light signal again into an electrical signal having its original frequency, amplitude and linearity.
- No modulator/demodulator is needed because the signal is transmitted optically all the way



➤ **Fig. 4.9** *Optically isolated isolation amplifier*

Capacitive Isolation

- The capacitive method uses digital encoding of the input voltage and frequency modulation to send the signal across a differential capacitive barrier.
- Separate power supply is needed on both sides of the barrier.
- Signals with bandwidths up to 70 kHz can be conveniently handled in this arrangement.



▸ **Fig. 4.10** *Capacitively coupled isolation amplifier*

The relative merits of the three types of isolation techniques are:

- All three types are in common use, though the transformer isolation amplifier is more popular.
- Opto-coupled amplifier uses a minimum number of components and is cost effective, followed by the transformer coupled amplifier.
- The capacitor coupled amplifier is the most expensive.
- Opto-isolated amplifiers offer the lowest isolation voltage (800 V continuous) between input and output; transformer coupled 1200 V and capacitance coupled 2200 V.
- Isolation resistance levels are of the order of 10^{10}, 10^{12} and 10^{12} ohms for transformer coupled, opto-coupled and capacitance coupled amplifiers respectively
- Gain stability and linearity are best for capacitance coupled versions—0.005%, and on par for the transformer and opto-coupled amplifier—0.02

Instruments such as electrocardiographs, pressure monitors, pressure transducers, pacemakers and others have been designed to electrically separate the portion of the circuit to which the patient is connected from the portion of the circuit connected to the ac power line and ground.