Lecture 5 (Signal conditioning)

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SIMULATED ELECTRONICS OF BIOLOGICAL SYSTEMS

RECORDING SYSTEMS

- Recorders
- Electronic recording system components
- Parts of medical signal conditioners
- Normalizing the transducers electrical signals
  - Adjusting the output to a common signal level
- Writing systems types
- Difference between transducers and electrodes

SIGNAL CONDITIONER FUNCTIONS

1. Signal amplifications
   - signals transducers small in magnitude. Amplifiers boost the level of the input signal to match the requirements of the recording/display system.
   - It is problem in applications where low-level signals are recorded at high off-ground voltages, or transmitted over distance or obtained in electromagnetic noise environments.
   - Using signal conditioners located closer to the signal source, or transducer, improves the signal-to-noise ratio of the measurement by boosting the signal level before it is affected by the environmental noise.

SIGNAL CONDITIONER FUNCTIONS

2. Frequency response
   - Bioelectric signals often contain extremely low frequency components. Two types of coupling are provided.
   - RC coupled amplifiers. Low frequency response require high C values.
   - Disadvantages of RC coupled amplifiers: Blocking of the amplifier in case of high level input. Long time constant cause the circuit to be unreceptive following each overdriving occurrence.
   - Direct coupled amplifiers. Disadvantages is that it tends to drift which means a change in the output with not related change in the input.

SIGNAL CONDITIONER FUNCTIONS

3. Filtering
   - Circuit amplifying some frequencies applied to the input while attenuating others.
   - Passive/Active filters
   - Low/high/band pass filters & notch filters
   - Example of notch filters is 50 Hz noise rejection picked up from power lines or machinery
   - Digital/Analog
   - Digital filters advantages are insensitivity to Temperature/ageing/voltage drift or external interference compared to analog filters.

SIGNAL CONDITIONER FUNCTIONS

4. Isolation
   - Pass the signal from its source to the measurement device without a physical or galvanic connection
5. Excitation
   - Generating excitation for the some transducers
   - Examples of transducers requiring voltage or current excitation are strain gauges and thermistors.
6. Linearization
   - Hardware or software linearization when the transducer response is non linear to the phenomenon being measured.

AMPLIFIER TYPES

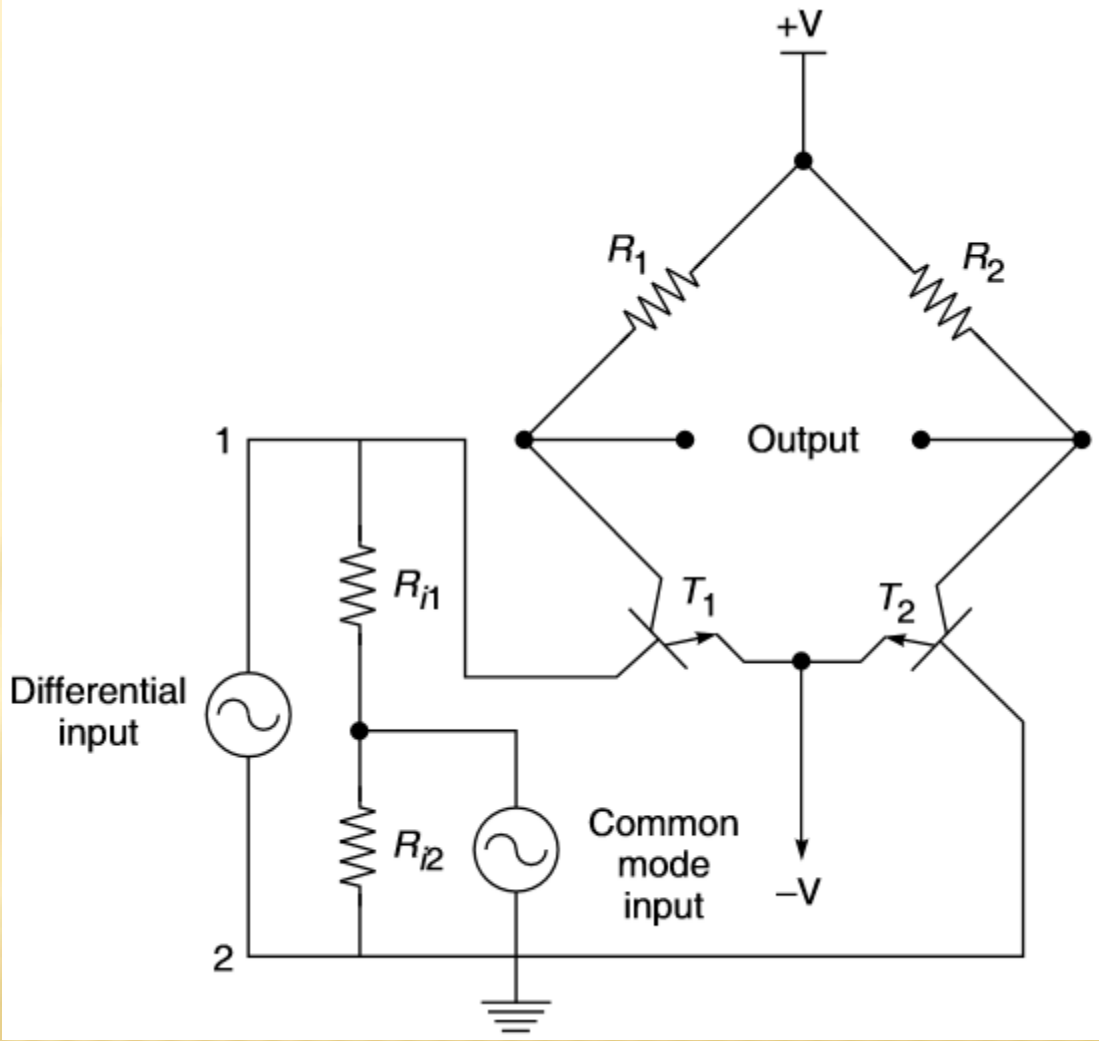
1. Differential Amplifiers
2. Ac coupled amplifiers
3. Carrier amplifiers
4. DC amplifiers
5. Chopper input dc amplifiers
6. Chopper stabilized dc amplifiers
7. DC bridge amplifiers

DIFFERENTIAL AMPLIFIERS

- Definition:
  - rejects any common mode signal that appears simultaneously at both amplifier input terminals and amplifies only the voltage difference that appears across them
- Advantages:
  - Rejecting common mode interference signals
  - Good stability: insensitive to drift due to temperature changes
  - Versatility: Adapted in many applications
- Differential mode signal
- Common mode signal
- CMRR Common Mode Rejection Ratio
- Decibels

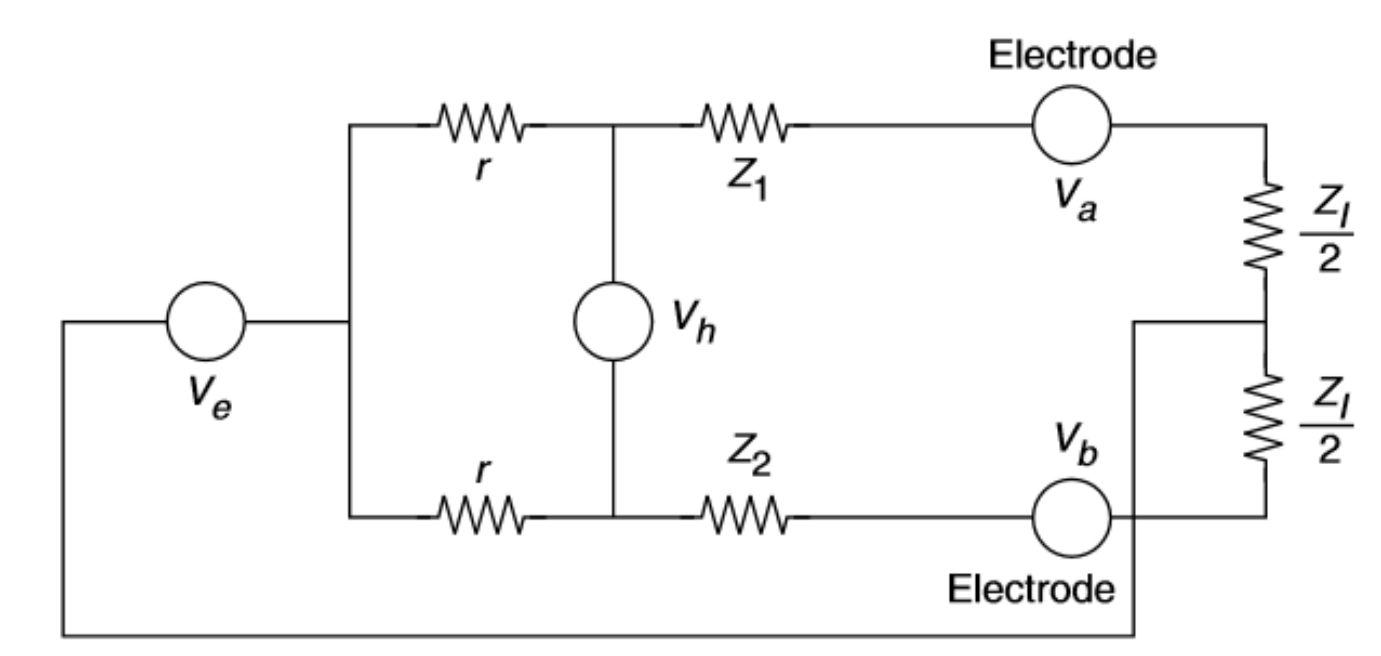
DIFFERENTIAL AMPLIFIER

- Working theory



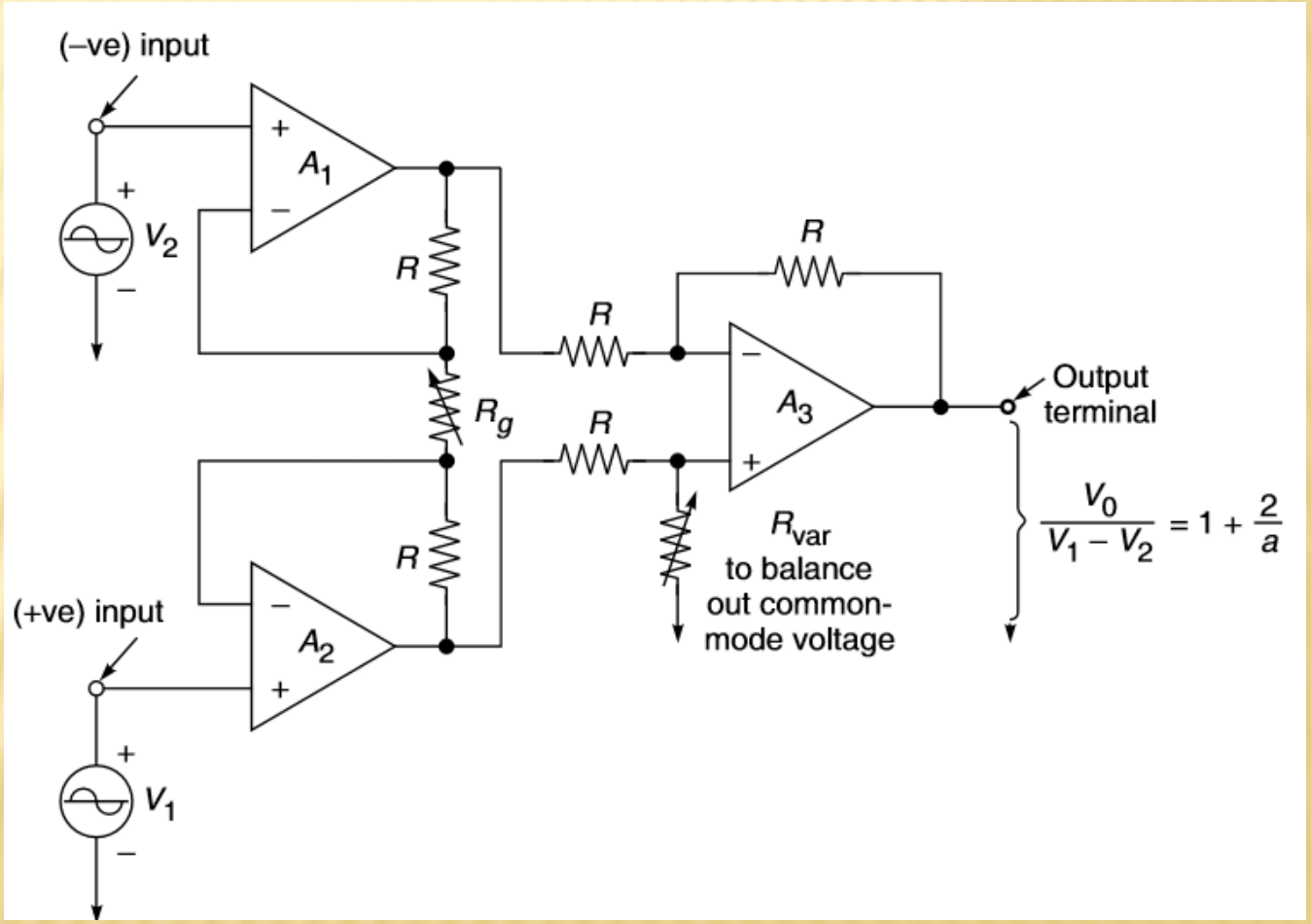
DIFFERENTIAL AMPLIFIER

- CMRR=$(Z_2-Z_1)/(Z_l/2)$
- High input impedance
- Electrode skin resistance should be low and as nearly equal as possible.



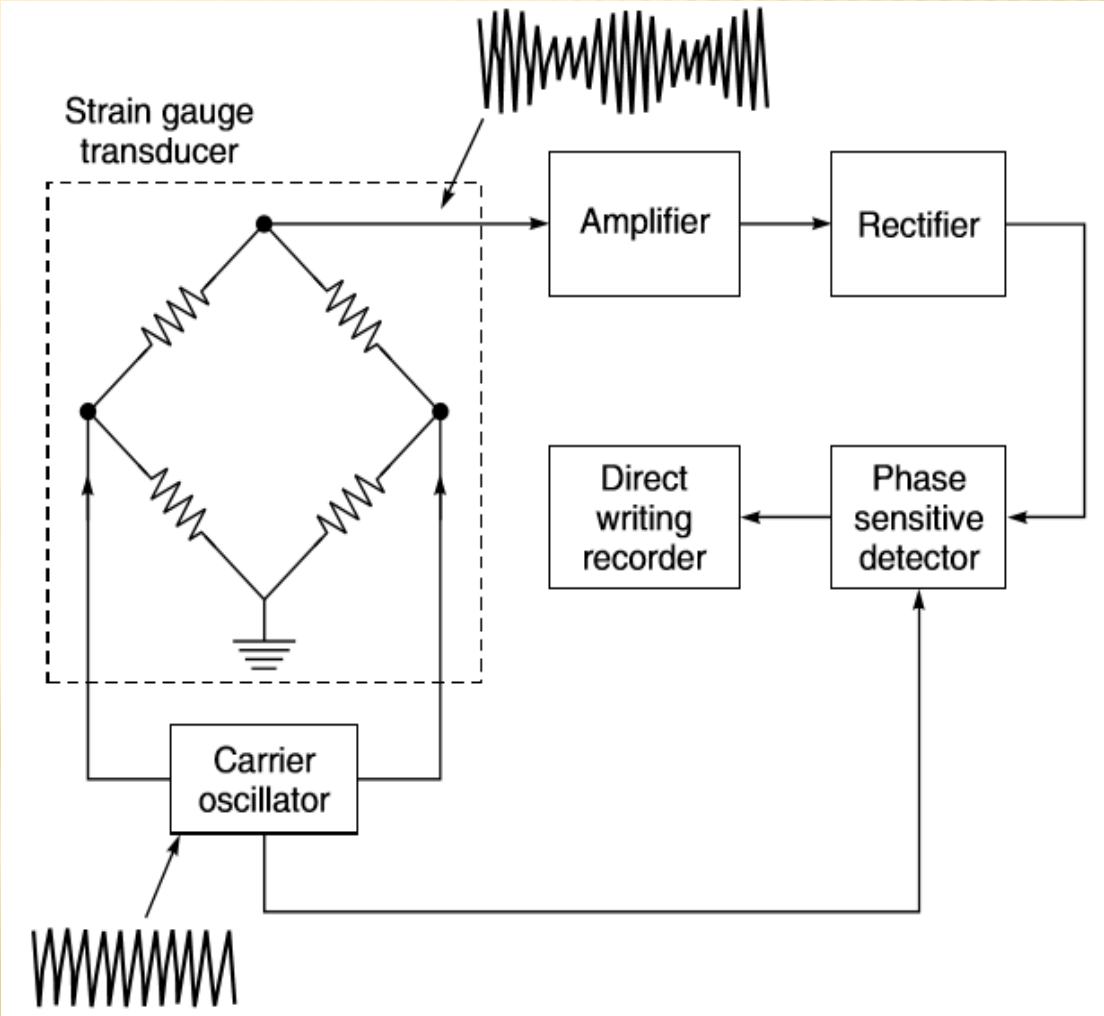
INSTRUMENTATION AMPLIFIER

- Differential amplifier limitation
- Description
- Advantages



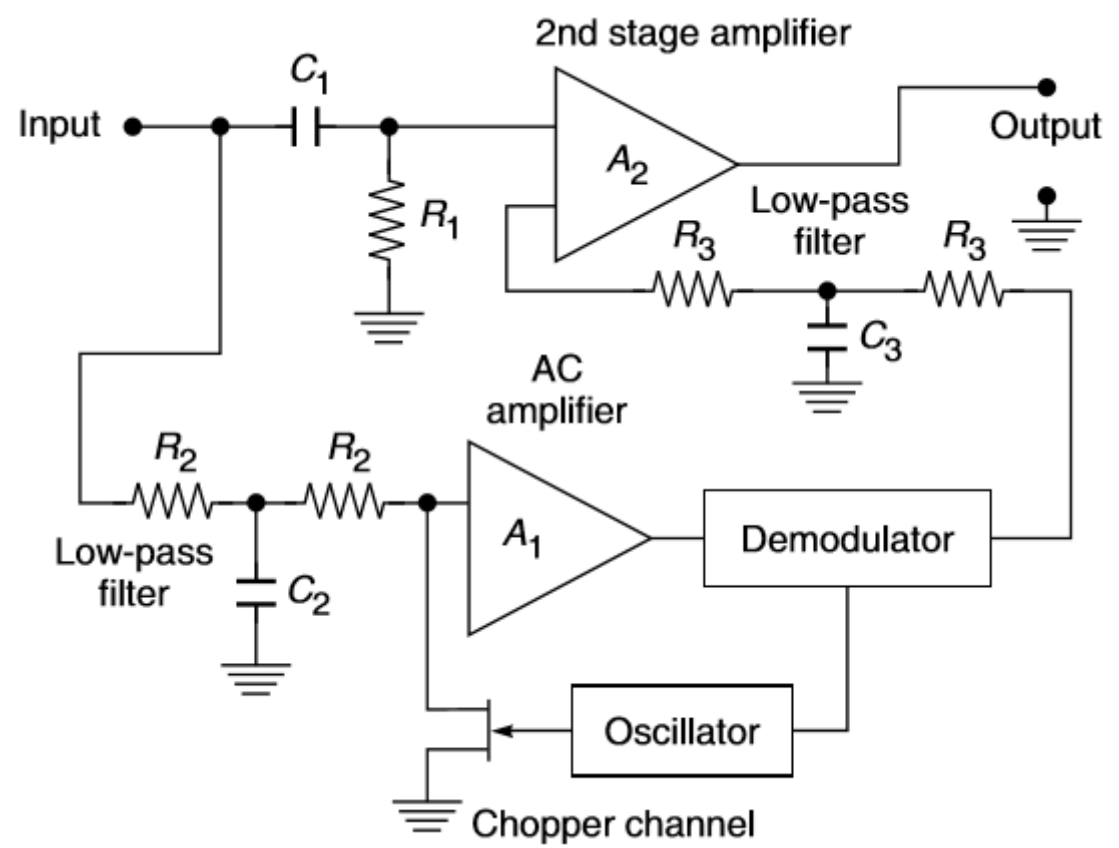
CARRIER AMPLIFIER

- Advantages
  - Zero frequency response of the dc amplifier
  - Stability of the capacitance coupled amplifier
  - Energize the transducer with AC voltage.
- Operation theory
- Difference between lock-in amplifiers and carrier amplifier



CHOPPER AMPLIFIER

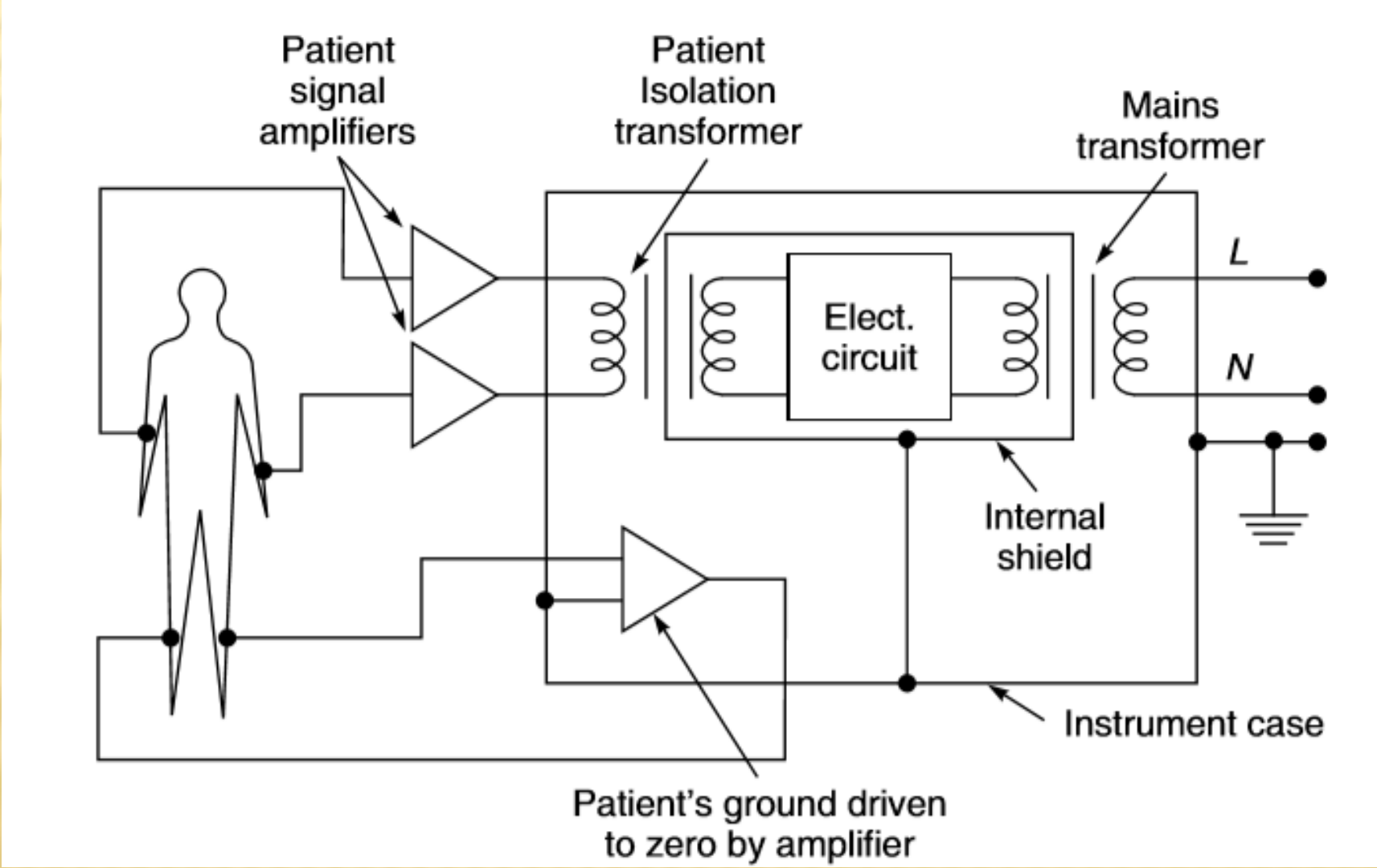
- Operation theory
- Advantages
  - Adequate low frequency response
  - Avoid drift problems
  - Insensitivity to component changes due to ageing, temperature changes, power supply variation or other environmental factors.



ISOLATION AMPLIFIERS

- Provides protection against leakage currents
- Types
  - Transformer isolation
  - Optical isolation
  - Capacitive isolation
- The difference between the three tequniques

TRANSFORMER ISOLATION



OPTICAL AND CAPACITIVE ISOLATION