BEANG 186B: Principles of Bioinstrumentation Design

Lecture 18

Design for Electrical Protection

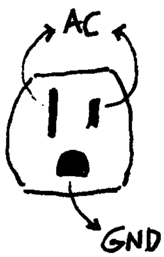
References

Webster, Ch. 14 (Sec. 14.3-14.9).

DESIGN FOR PROTECTION

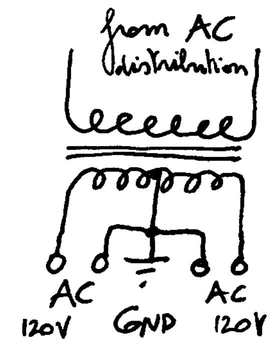
- Source of macroshock / microshock hazards: typically GROUND CURRENTS
    - wireless or implanted systems → no issue! (no ground current path)
    - wireline systems → avoid GROUND FAULTS

Typical distribution of line power (Chap. 14.3)



Receptacle

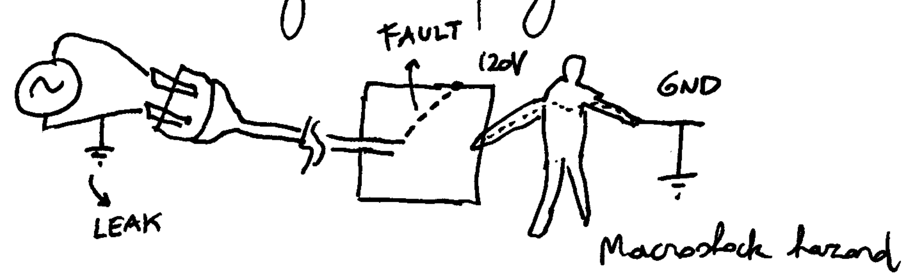
supplied through transformer:



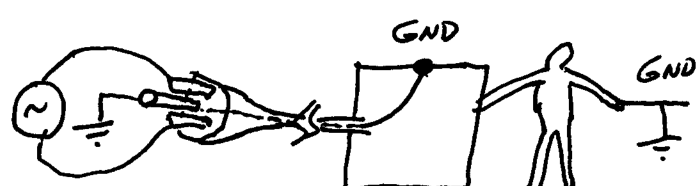
(Fig. 14.8)

- Always ground the chassis of the bioinstrument! Don't use ungrounded plugs:

UNGROUNDED:



GROUNDED:



- Additional protection at power distribution:
    circuit breakers (always); surge protectors; etc.

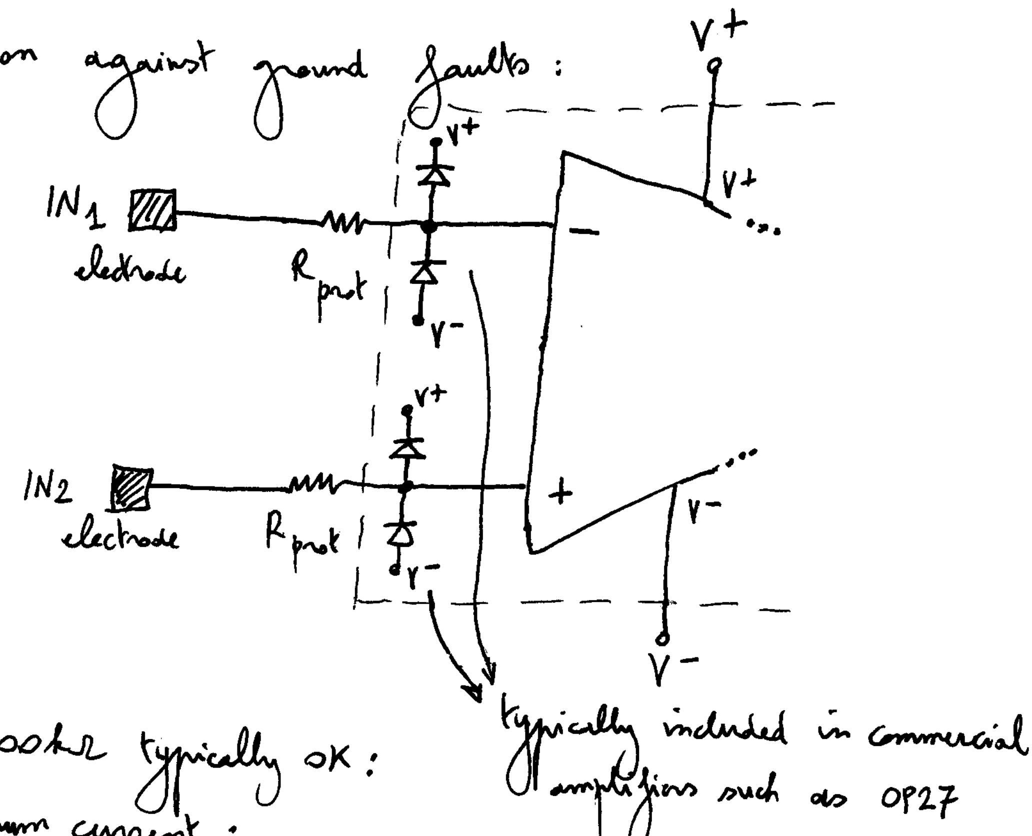
– Equipment design for protection → Sec. 14.9, and Chap. 6 revisited

- Electrical isolation, when feasible : SEPARATE GROUNDS
  e.g. : • optocouplers (V or I → light → V or I)
  • wireless power/telemetry (for many great reasons!)
  → see guest lectures

- Circuit protection against ground faults :

– INPUTS :

e.g. :



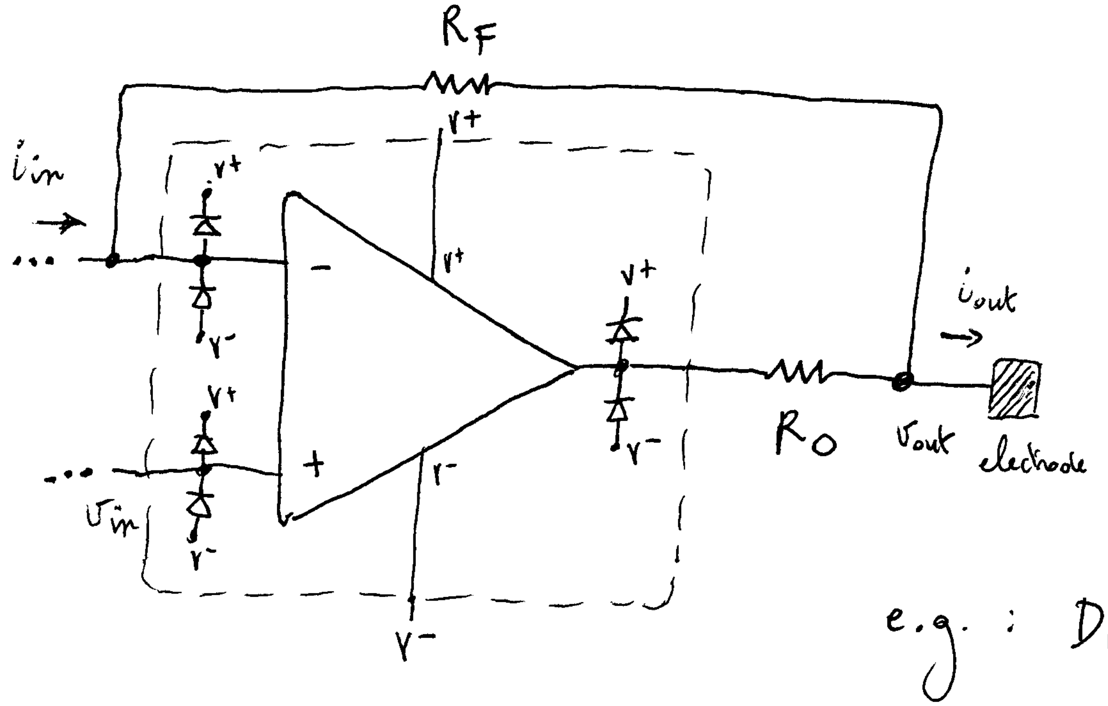
$R_{prot} = 100k\Omega$ typically OK :
maximum current :

$$V_{AC} / R_{prot} = 120V / 100k\Omega = 1.2mA \text{ (OK)}$$

– OUTPUTS :

Can't add a large R_{prot} in series with the output!
(because $R_{out} \geq R_{prot}$)

SOLUTION : add the resistance BEFORE the feedback :



e.g.: DRL (Chap. 6)

⇒

- Output impedance is low as desired (typically ~100Ω, way smaller than the electrode impedance onto the body)

  $R_{out} \ll R_o$! because the high-gain negative feedback: $v_{out} = v_{in} - R_F\, i_{in}$ independent of i_{out} as long as the opamp is not saturated.

- Maximum output current is low as desired owing to opamp saturation

  $i_{out\ max} \approx V^+ / R_o$

  $i_{out\ min} \approx V^- / R_o$

  typically μA's for low V^+ and V^-

ground fault: $V_{AC} / R_o = 120V / 100\,k\Omega = 1.2\,mA$

OK