Electrical Safety

Hsiao-Lung Chan, Ph.D.
Dept Electrical Engineering
Chang Gung University, Taiwan
chanhl@mail.cgu.edu.tw

Macroshock hazard

- Stimulation through the skin

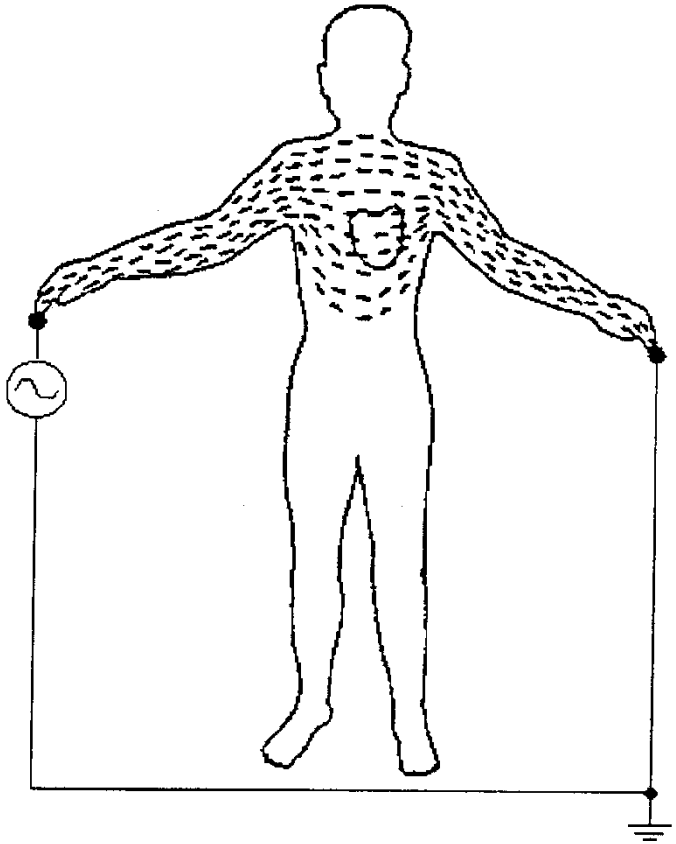
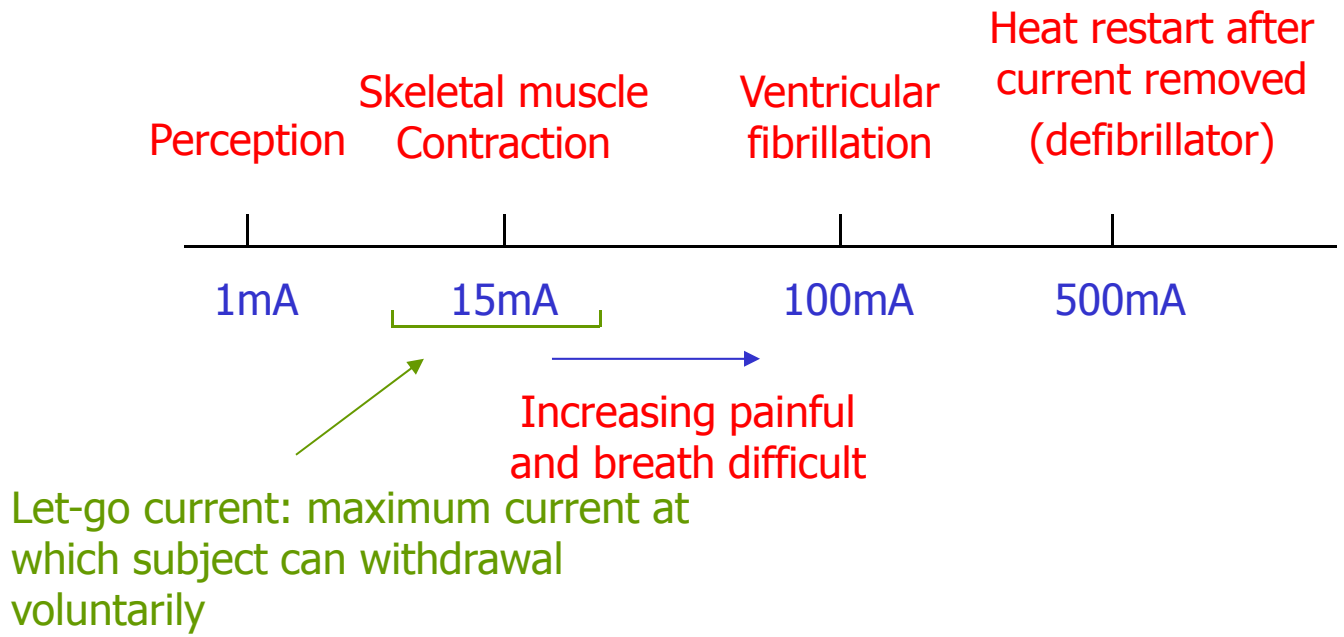


Figure from J. Enderle, Introduction to Biomedical Engineering, Academic Press, 2000.

Physiological effect by macroshock

- Stimulation through the skin (Cont.)
  - An alternating current at 50/60 Hz is applied:



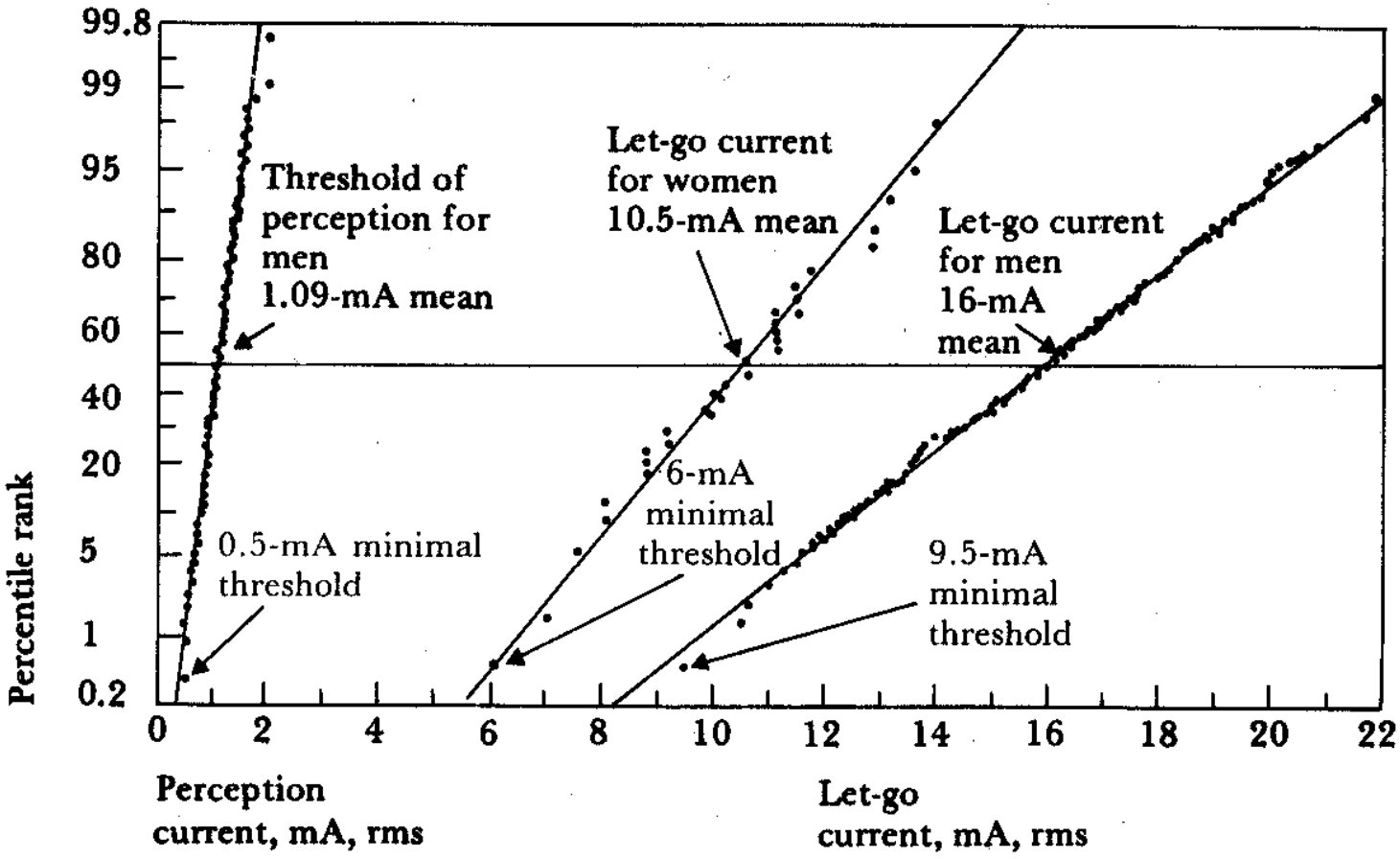


Figure 14.2 Distributions of perception thresholds and let-go currents These data depend on surface area of contact (moistened hand grasping AWG No. 8 copper wire). (Replotted from C. F. Dalziel, "Electric Shock," *Advances in Biomedical Engineering*, edited by J. H. U. Brown and J. F. Dickson III, 1973, 3, 223–248.)

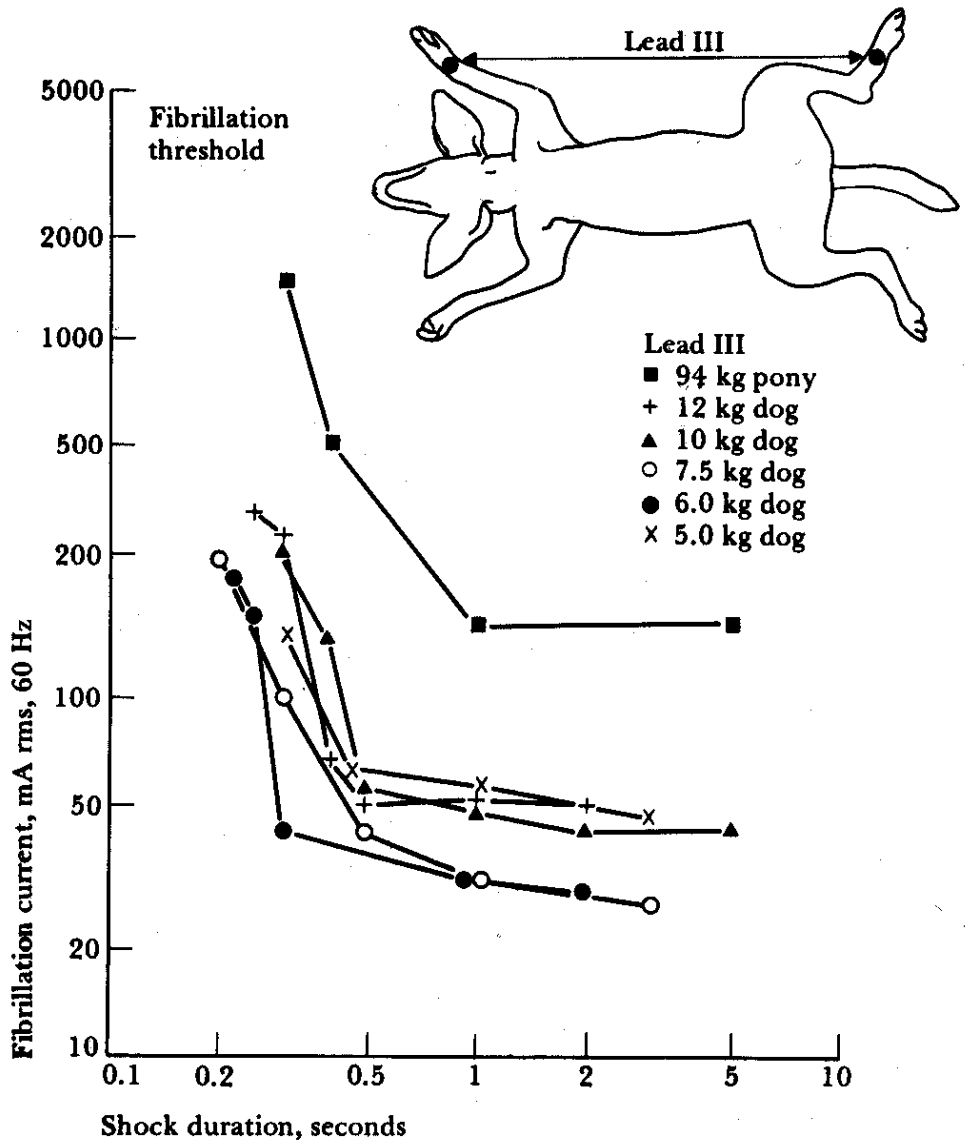


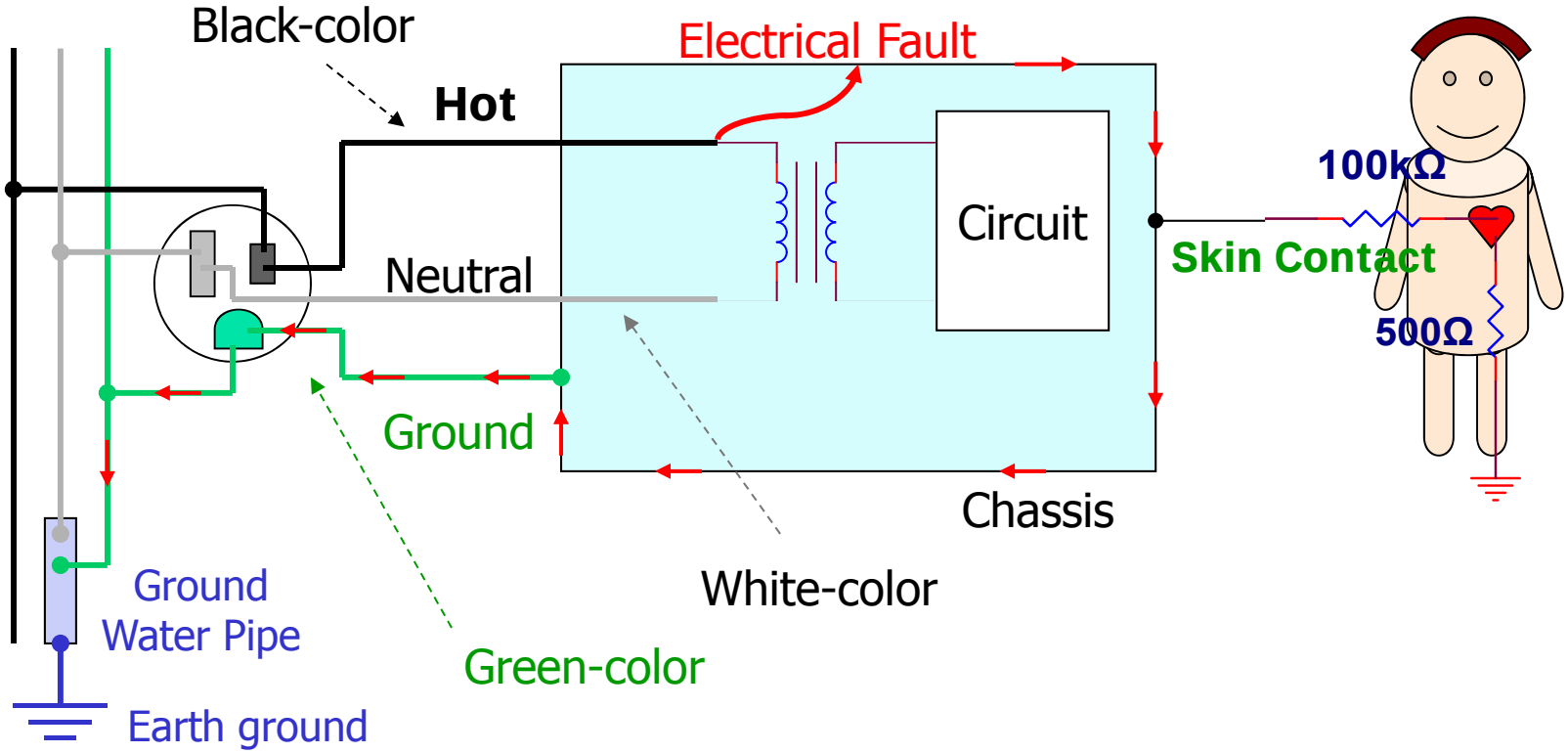
Figure 14.4 Thresholds for ventricular fibrillation in animals for 60-Hz ac current. Duration of current (0.2 to 5 s) and weight of animal body were varied. (From L. A. Geddes, *IEEE Trans. Biomed. Eng.*, 1973, 20, 465–468. Copyright 1973 by the Institute of Electrical and Electronics Engineers. Reproduced with permission.)

Physiological effect by macroshock

- Depend on skin impedance: If a 240V is applied to skin
  - Dry skin (10 ~ 100 kΩ): 25 ~ 2.5 mA
  - Gripped connection (1kΩ): 250 mA
  - Wet skin (100Ω): 2.5 A

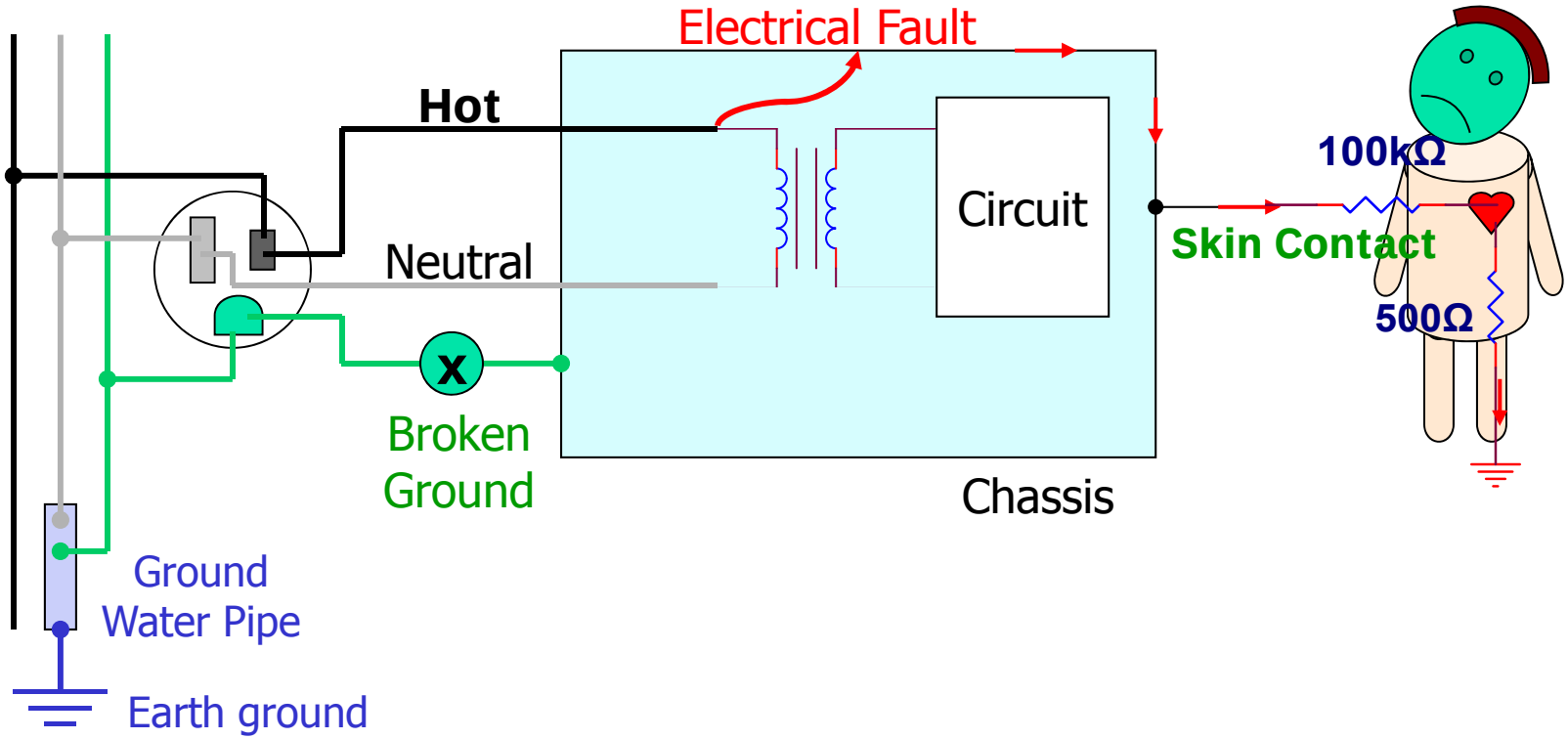
Macroshock hazard by electrical fault

- Grounded case



Macroshock hazard (cont.)

- Ungrounded case or broken ground



Microshock

- Direct stimulation of the heart
  - Cardiac Catheter
  - 100μA can cause ventricular fibrillation

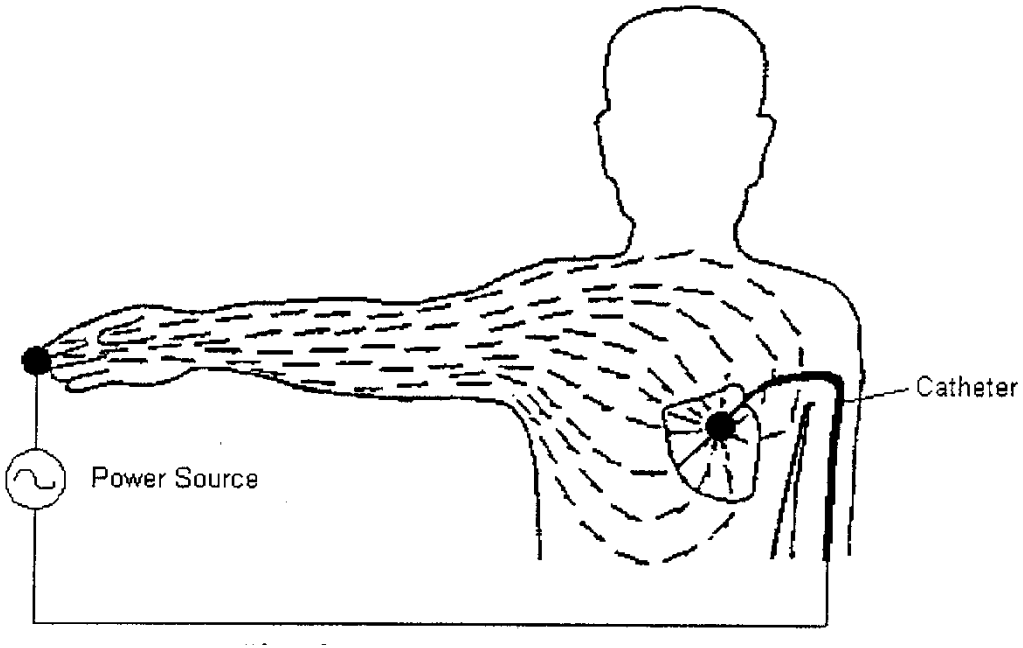
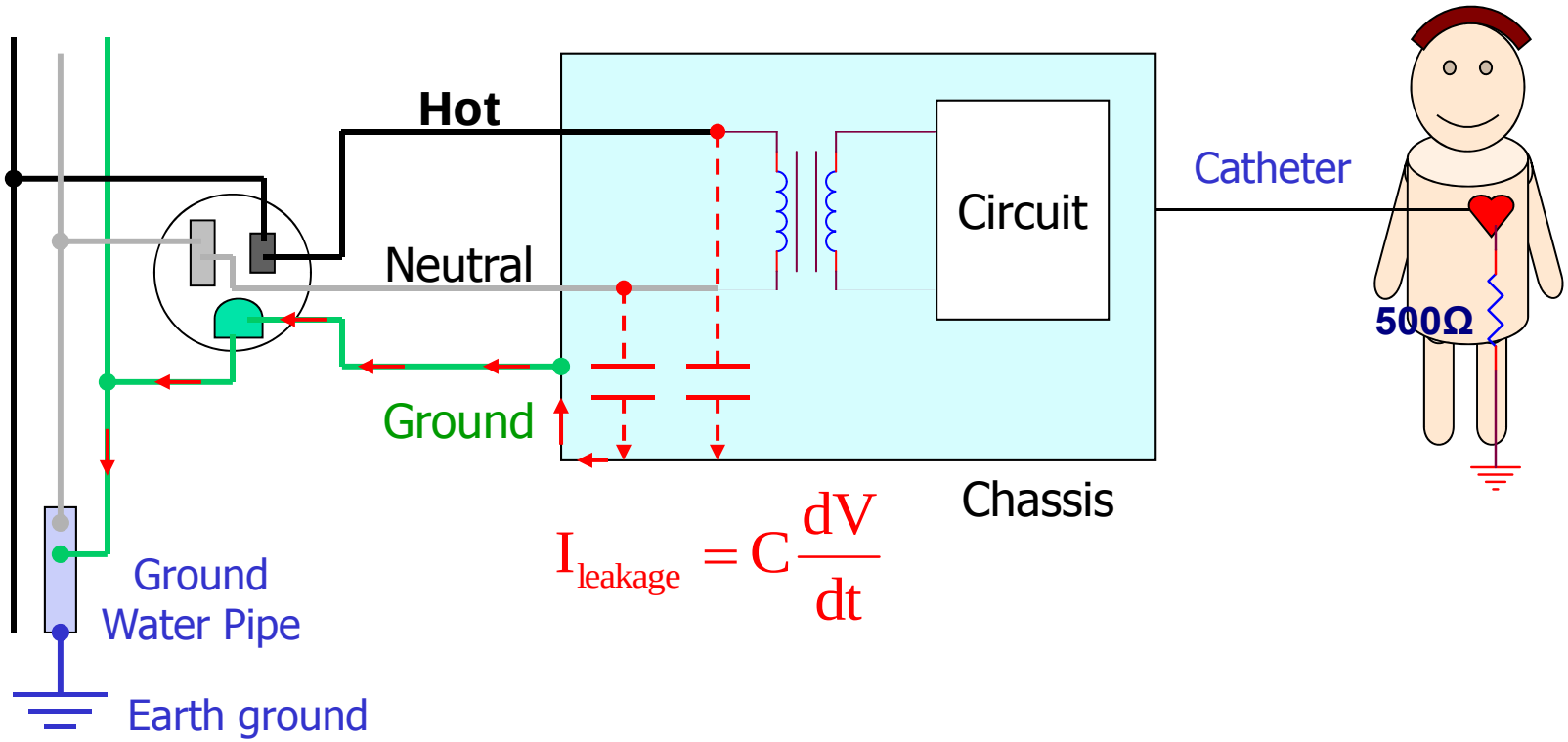


Figure from J. Enderle, Introduction to Biomedical Engineering, Academic Press, 2000.

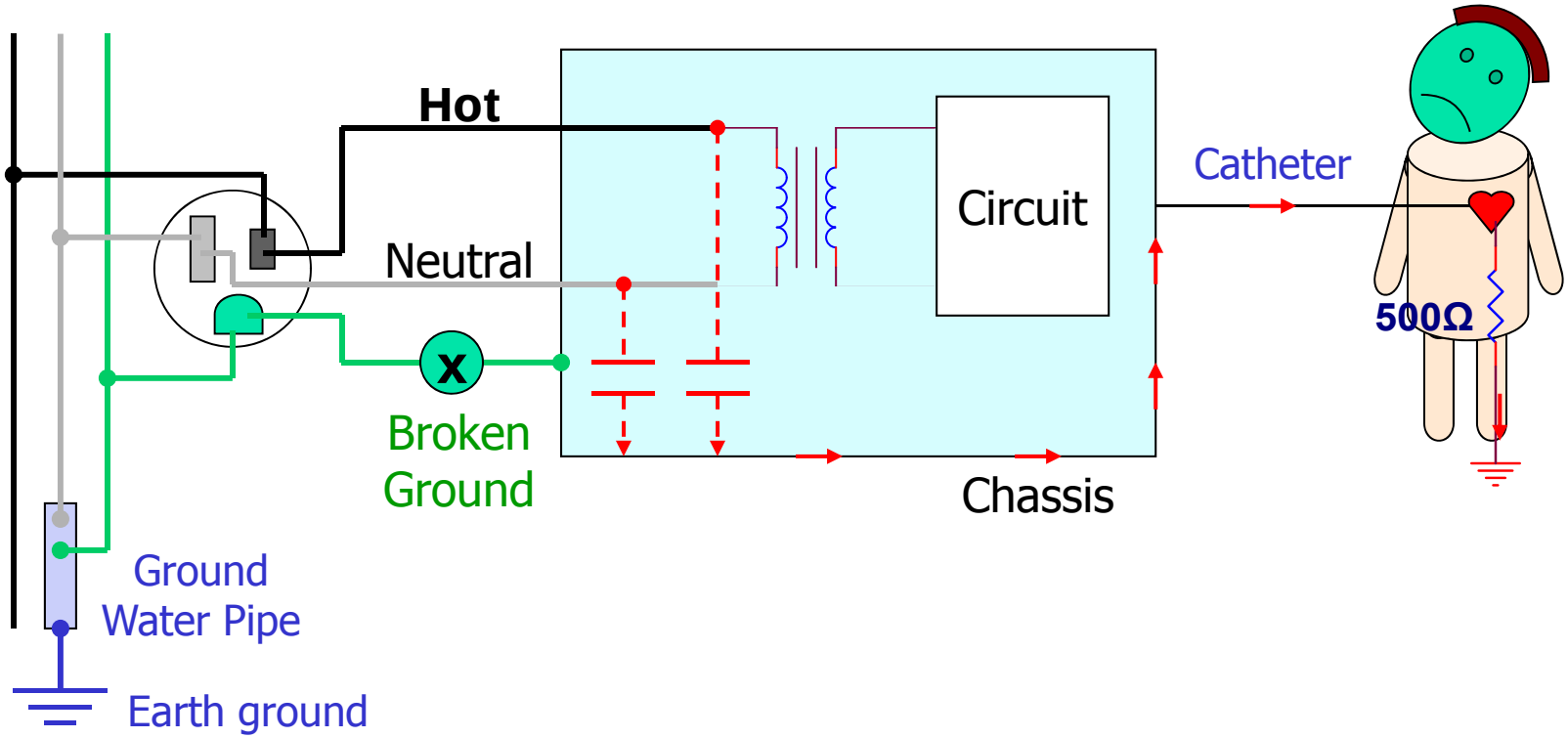
Microshock harzard by leakage current

- Leakage current pathway: intact ground



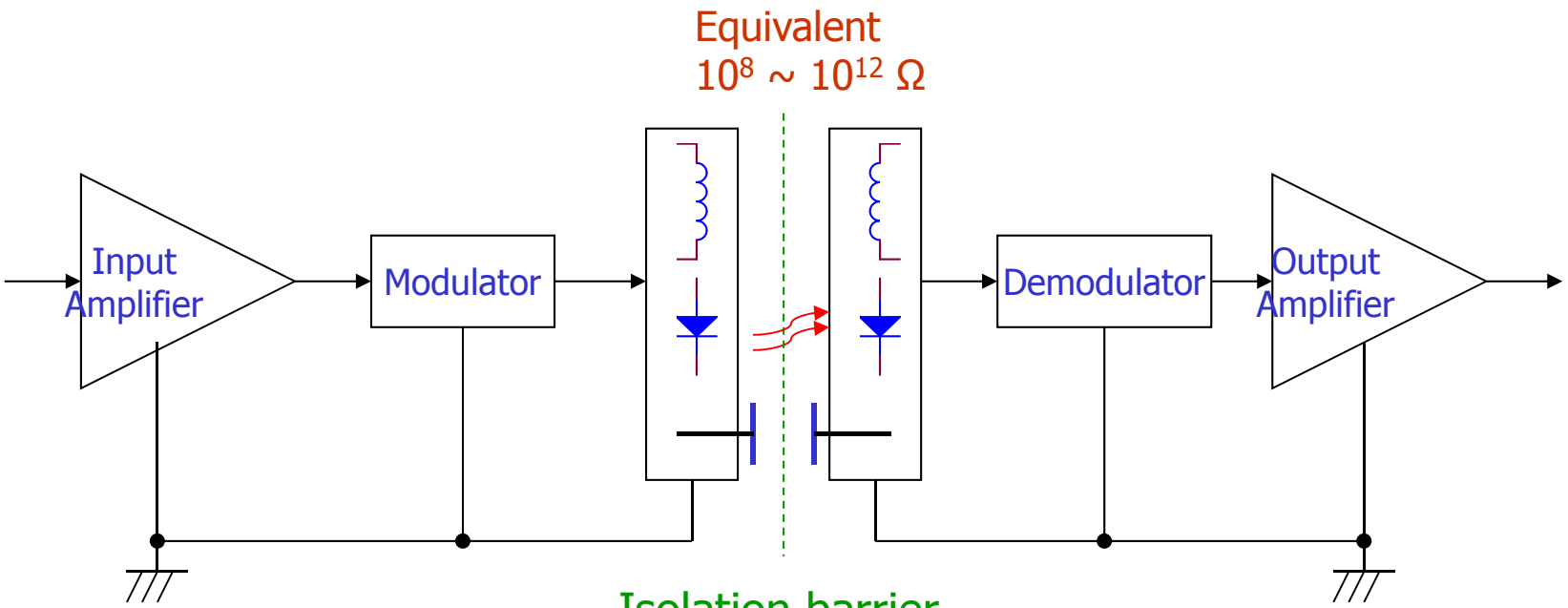
Microshock harzard (cont.)

- Leakage current pathway: broken ground (1)

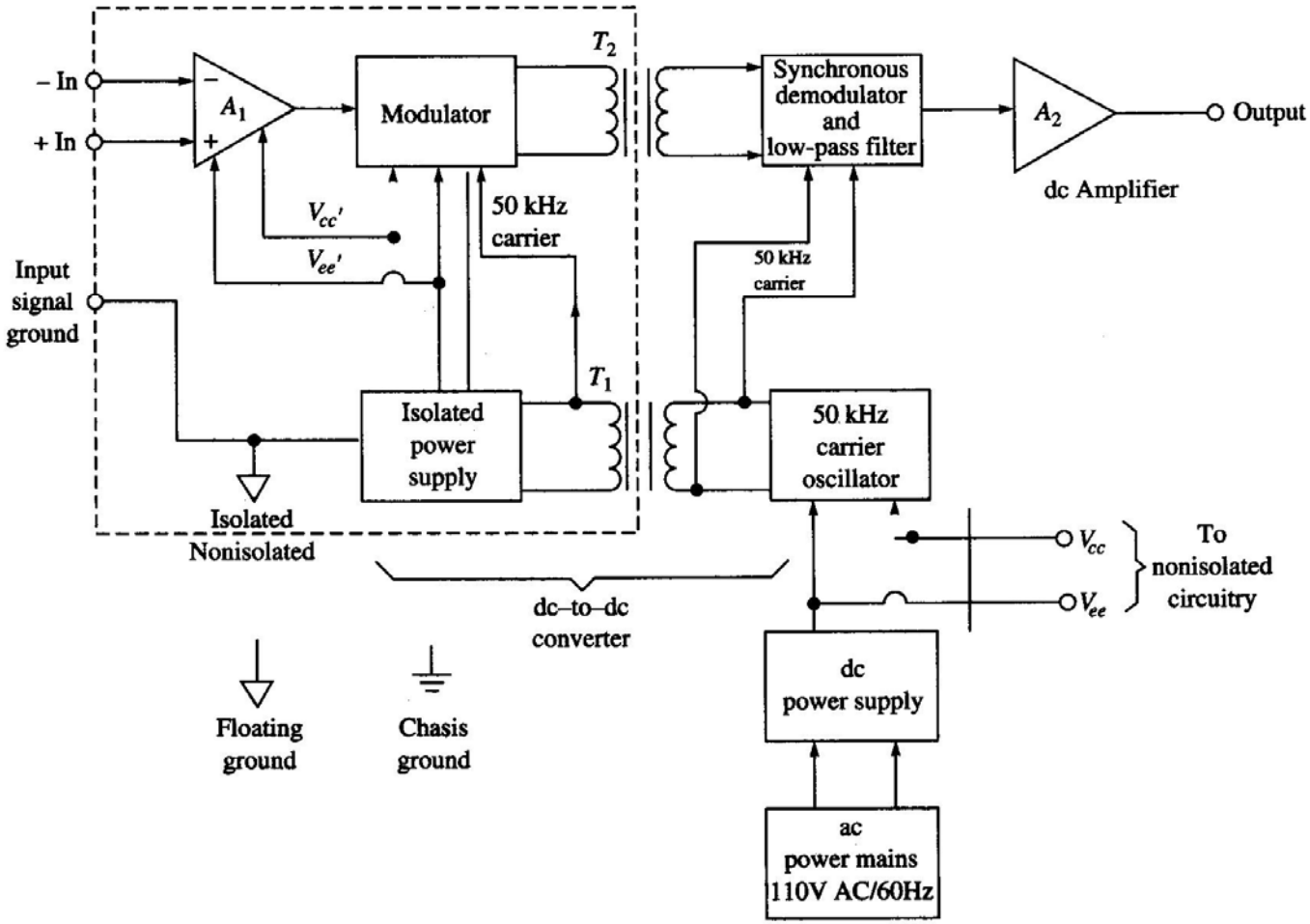


Isolation amplifier

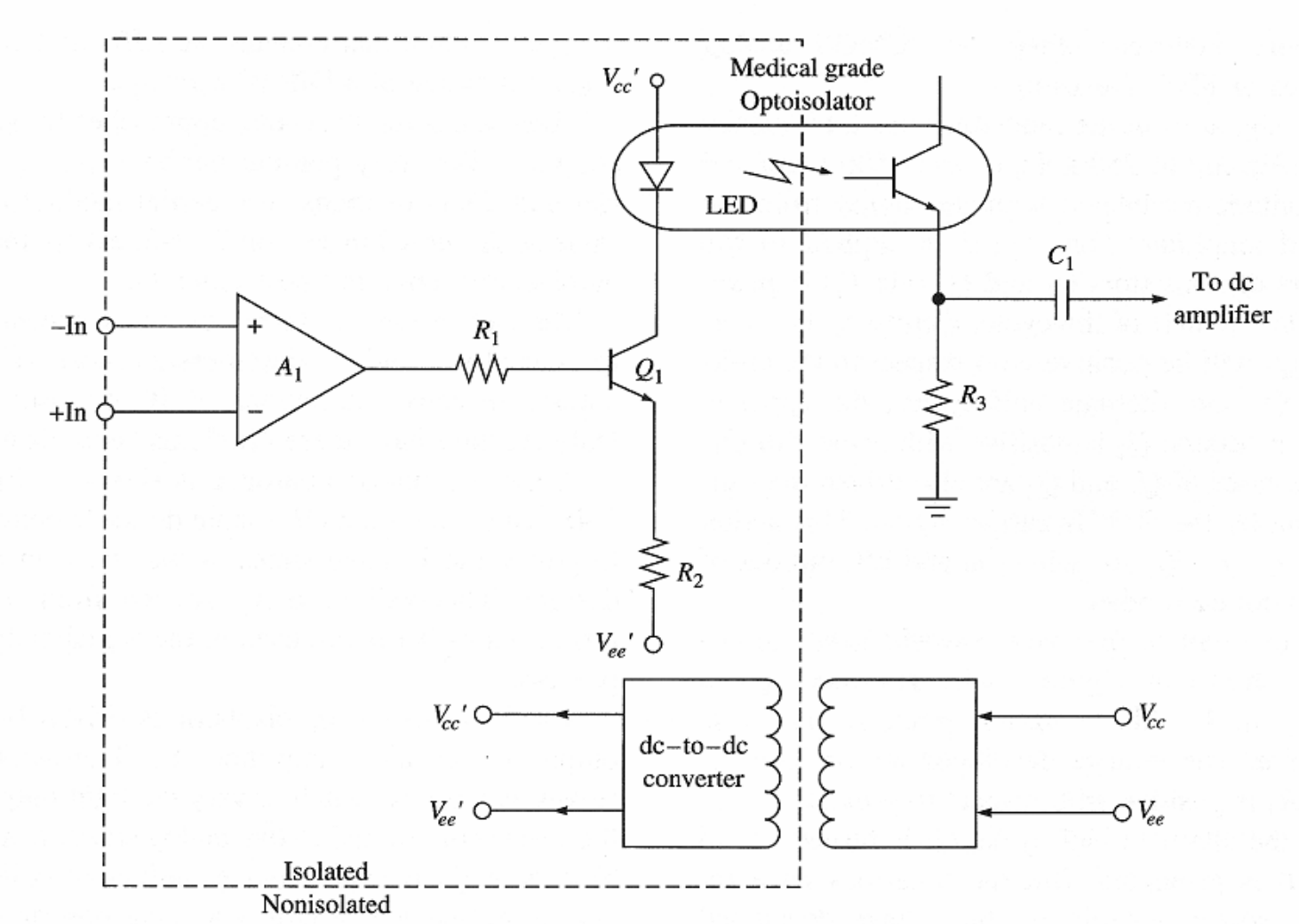
- Basic architecture



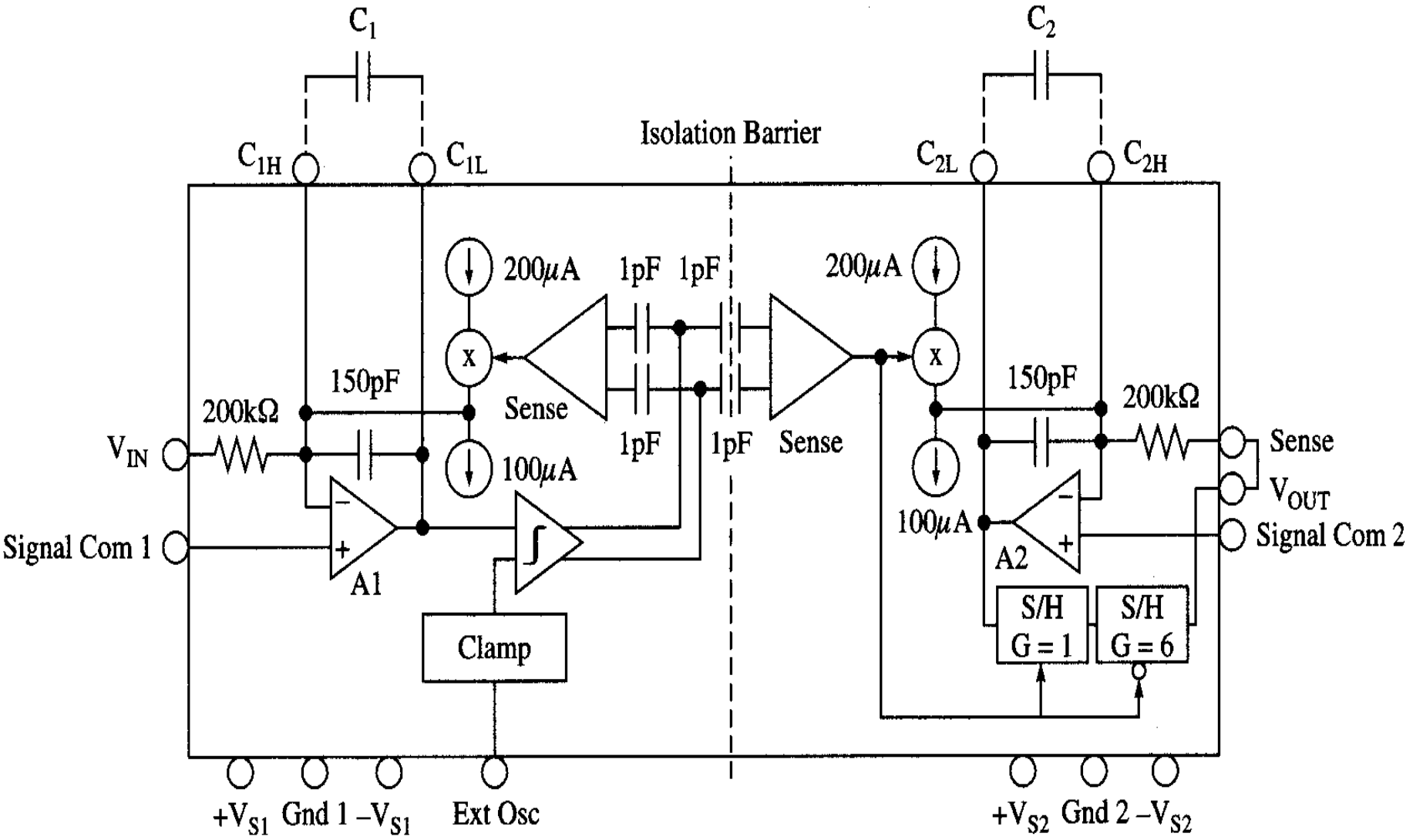
Transformer-coupled isolation amplifier



Optical-coupled isolation amplifier



Capacitive isolation amplifier (ISO121, Burr-Brown Corporation)



Reference

- G. D. Baura, "Medical device technologies," Elsevier Inc., 2012.
- John Enderle, Susan Blanchard, Joseph Bronzino, Introduction to Biomedical Engineering, Academic Press, 2000.
- John G. Webster, Medical Instrumentation, application and design, 3rd Ed., Houghton Mifflin, 2000