BENG 186B: Principles of Bioinstrumentation Design

Lecture 17

Electrical Safety and Physiological Effects

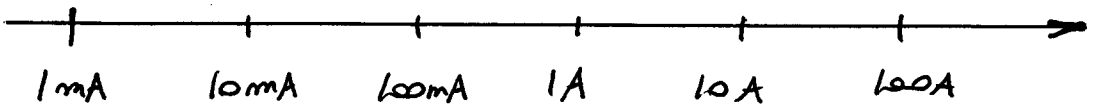
References

Webster, Ch. 14 (Sec. 14.1-14.2).

ELECTRICAL SAFETY → Chap. 14

- Physiological effects (Sec. 14.1):

1-3 seconds exposure ; 70 kg body mass ; copper wires to both hands:



THRESHOLD OF PERCEPTION

LET-GO CURRENT : maximum current for which subject can withdraw.

RESPIRATORY PARALYSIS ; fatigue ; pain

(*) VENTRICULAR FIBRILLATION : induced rapid, disorganized cardiac rhythm → MAJOR CAUSE OF DEATH

(+) SUSTAINED MYOCARDIAL CONTRACTION; burns; injury

(*): only if the heart is in the path of the current

- Important parameters of susceptibility (Sec. 14.2):
  - frequency & duration of the current
  - body size / weight
  - point of entry: path through the body (*)

- Frequency: 10 Hz – 1,000 Hz (including 60 Hz AC power!) range is most susceptible (lowest let-go currents)

- Duration: The effect of a current pulse of duration d on the body is modeled as a first-order system:

$$\text{Effect over } d = \left(1 - e^{-d/\tau}\right) \cdot \text{Effect over } \infty \text{ duration}$$

or:

$$I_d = \frac{1}{1 - e^{-d/\tau}} \cdot I_r$$

I_d: stimulation current threshold @ d

I_r: RHEOBASE CURRENT: stimulation current threshold @ ∞ duration

τ: membrane time constant ($=R.C$) of the myocardiac cells $\approx$ 2 ms (typical)

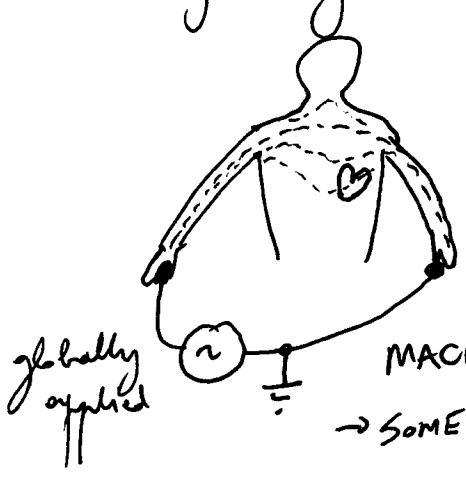
$\Rightarrow$ for $d \gg \tau$: $I_d \cong I_r$, i.e. CURRENT is important

for $d \ll \tau$: $I_d \approx \frac{\tau I_r}{d}$, i.e. CHARGE is important

$\left(\underbrace{d I_d}_{Q_d} \cong \underbrace{\tau I_r}_{Q_r} \right)$

Q_r: stimulation charge threshold

- Points of entry:



vs.