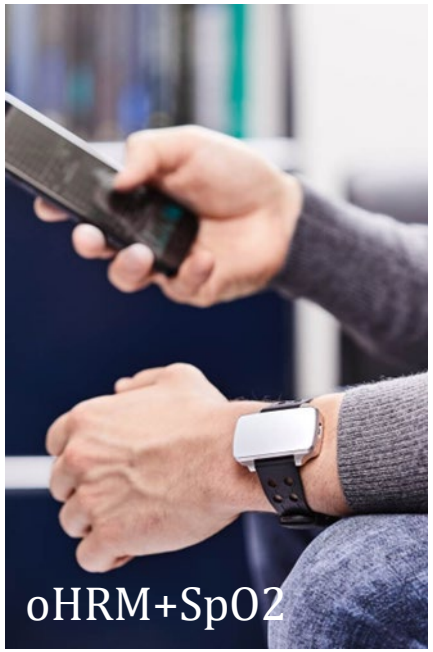
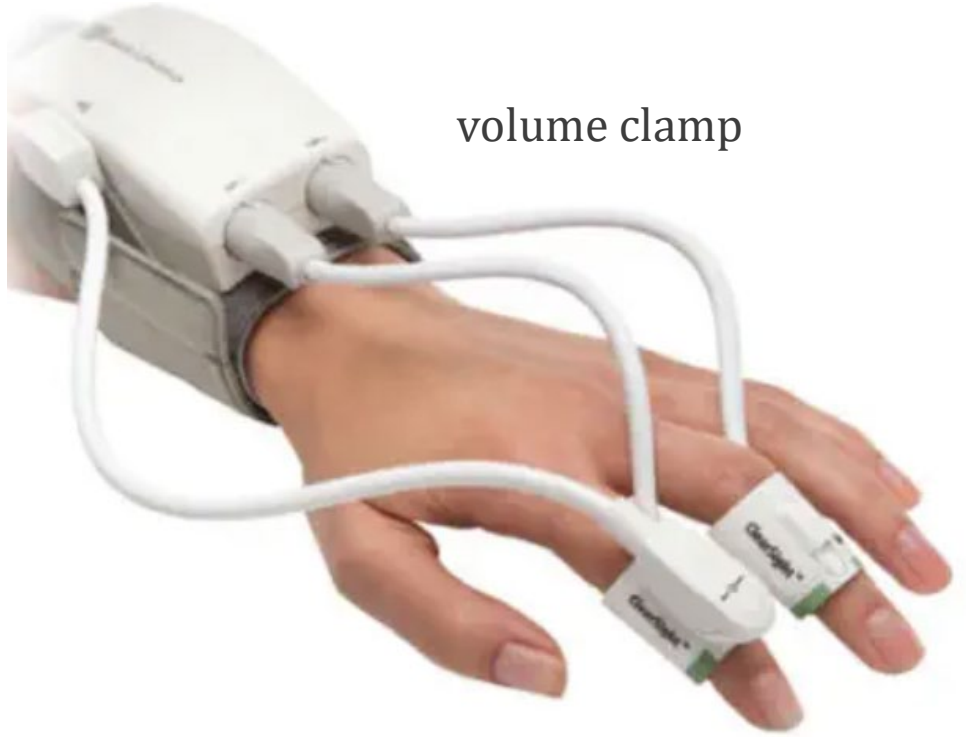
Communications

- Student feedback: below 6, they are not visible to me

EE-511 Sensors in medical instrumentation
Chapter 5 – Photo-plethysmography


oHRM


oHRM+SpO2

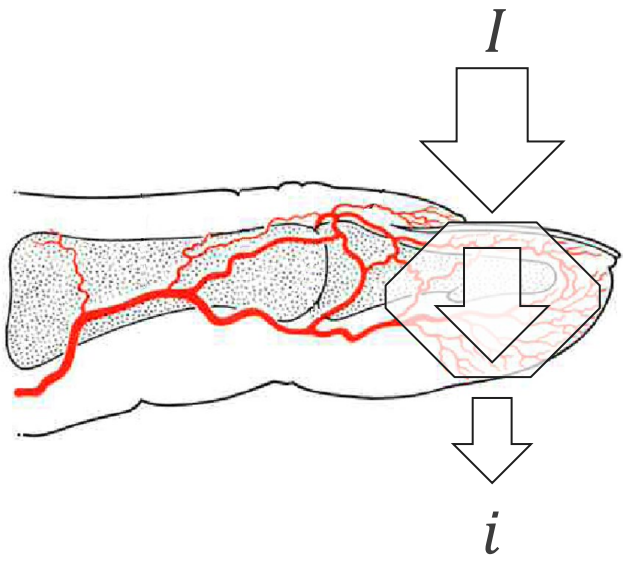

volume clamp

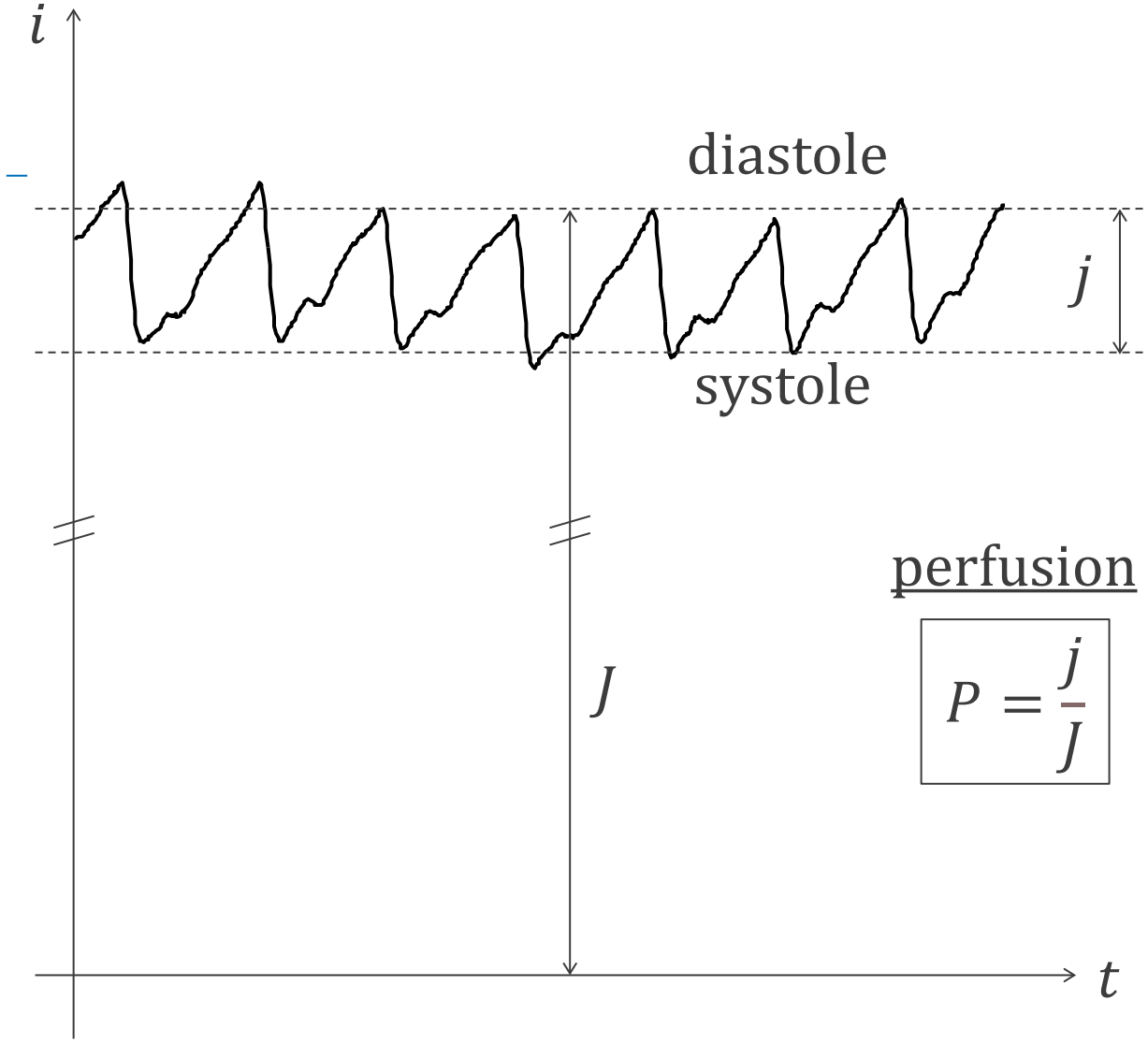

AKTiiA
oBPM®
127/82


oBPM®

5.1.1 PPG signal

- PPG = photoplethysmography



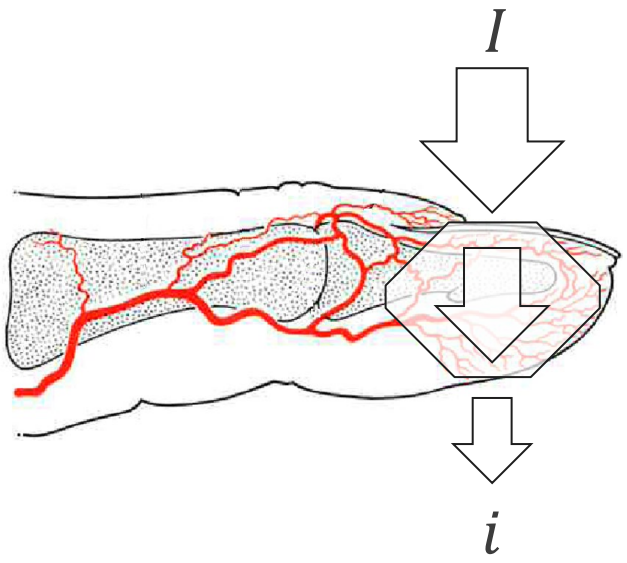


perfusion

$$P = \frac{j}{J}$$

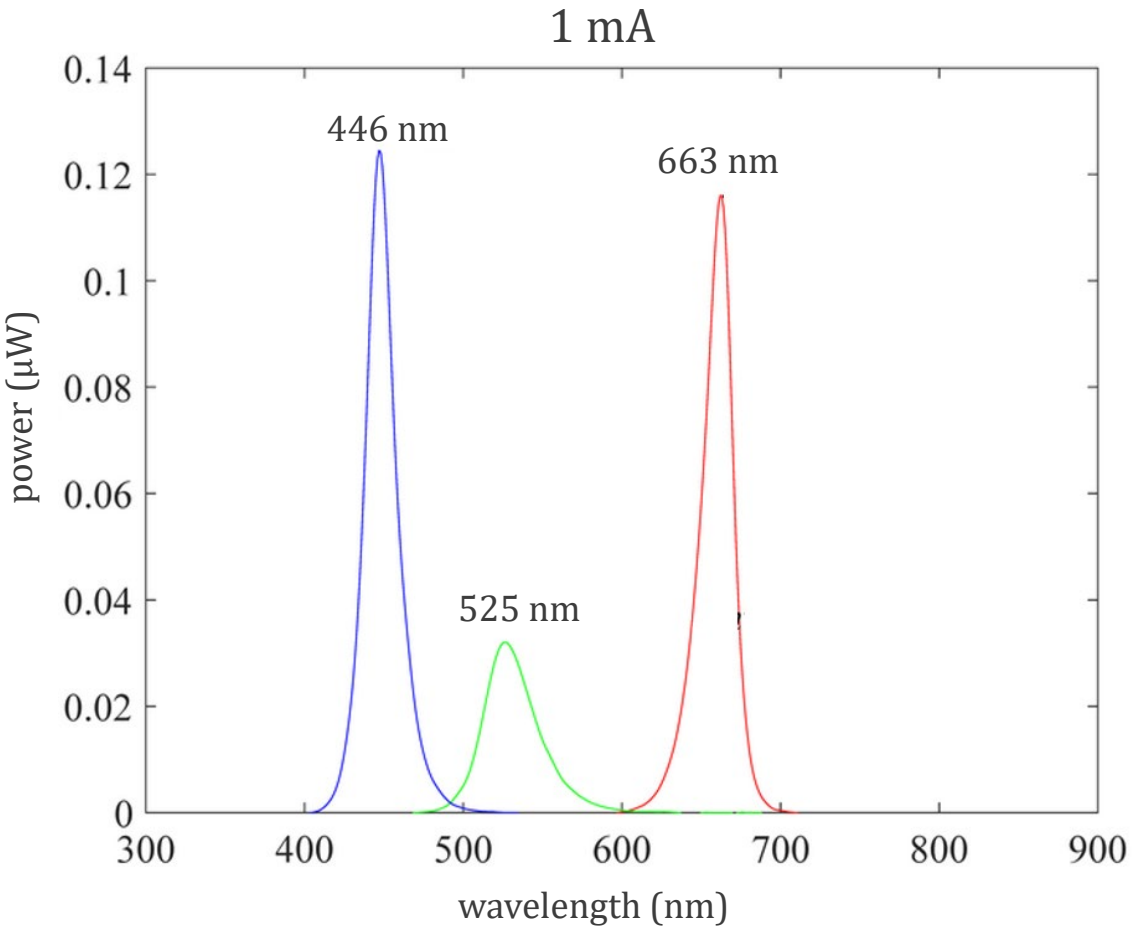
5.1.1 PPG signal (continued)

transmission mode



reflection mode

5.1.1 PPG signal (continued)



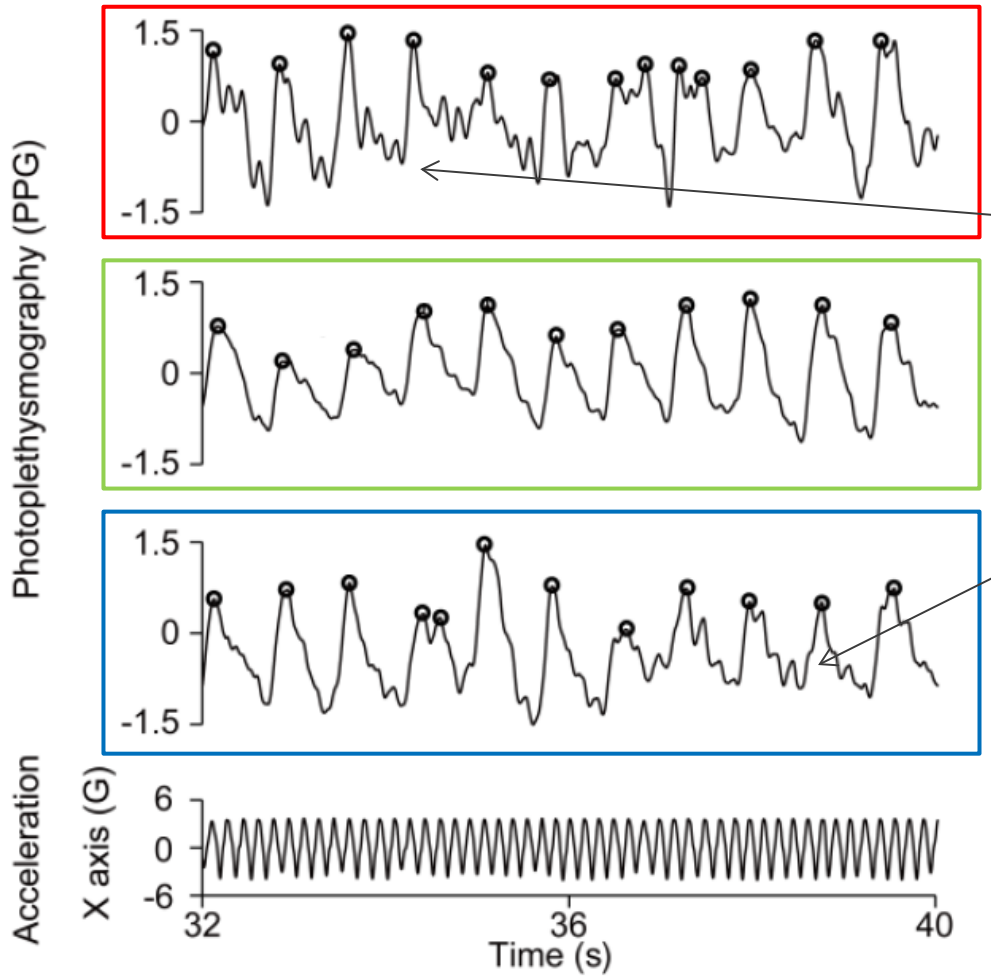
10.3390/s19245441

What wavelength to use?

green LEDs are the less efficient

5.1.1 PPG signal (continued)

What wavelength to use?



motion artifacts

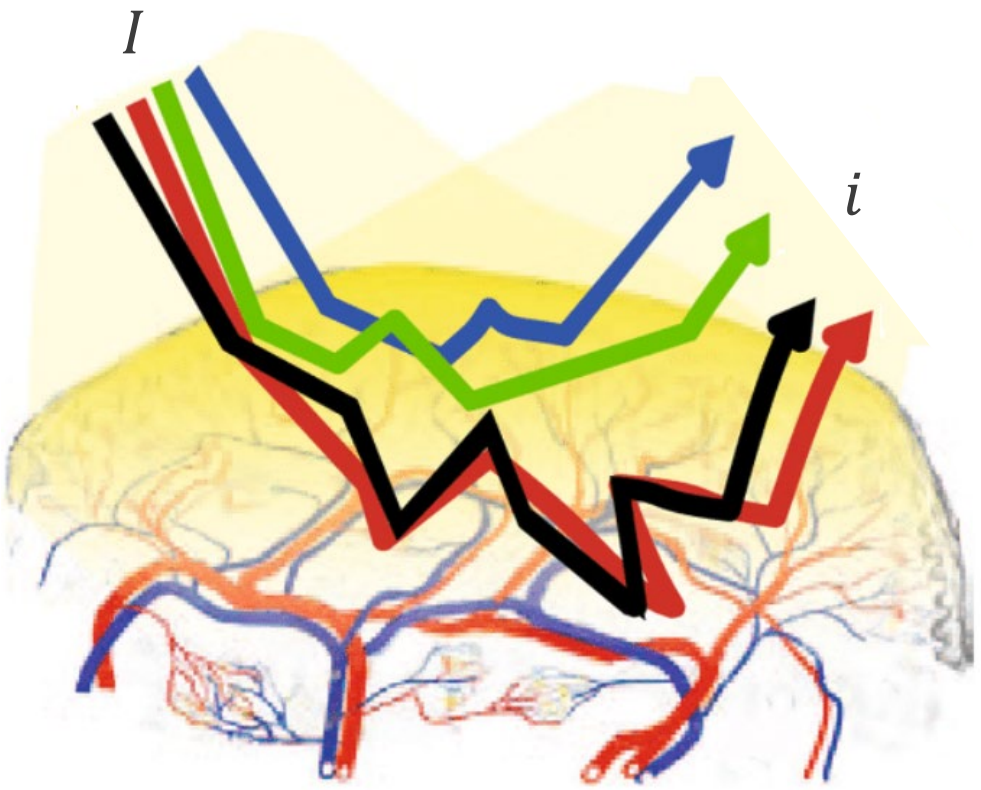
best

motion

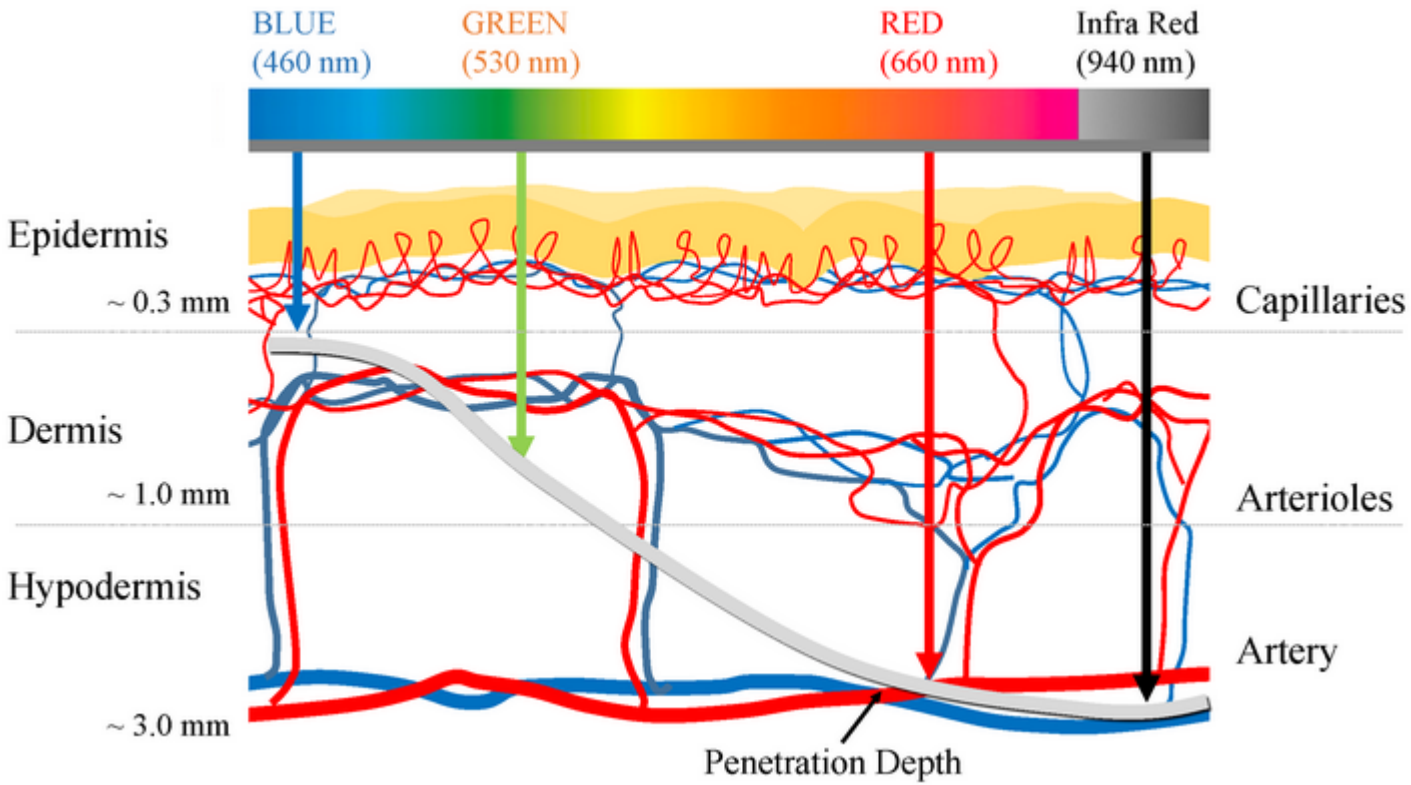
10.1109/EMBC.2013.6609852

5.1.1 PPG signal (continued)

What wavelength to use?



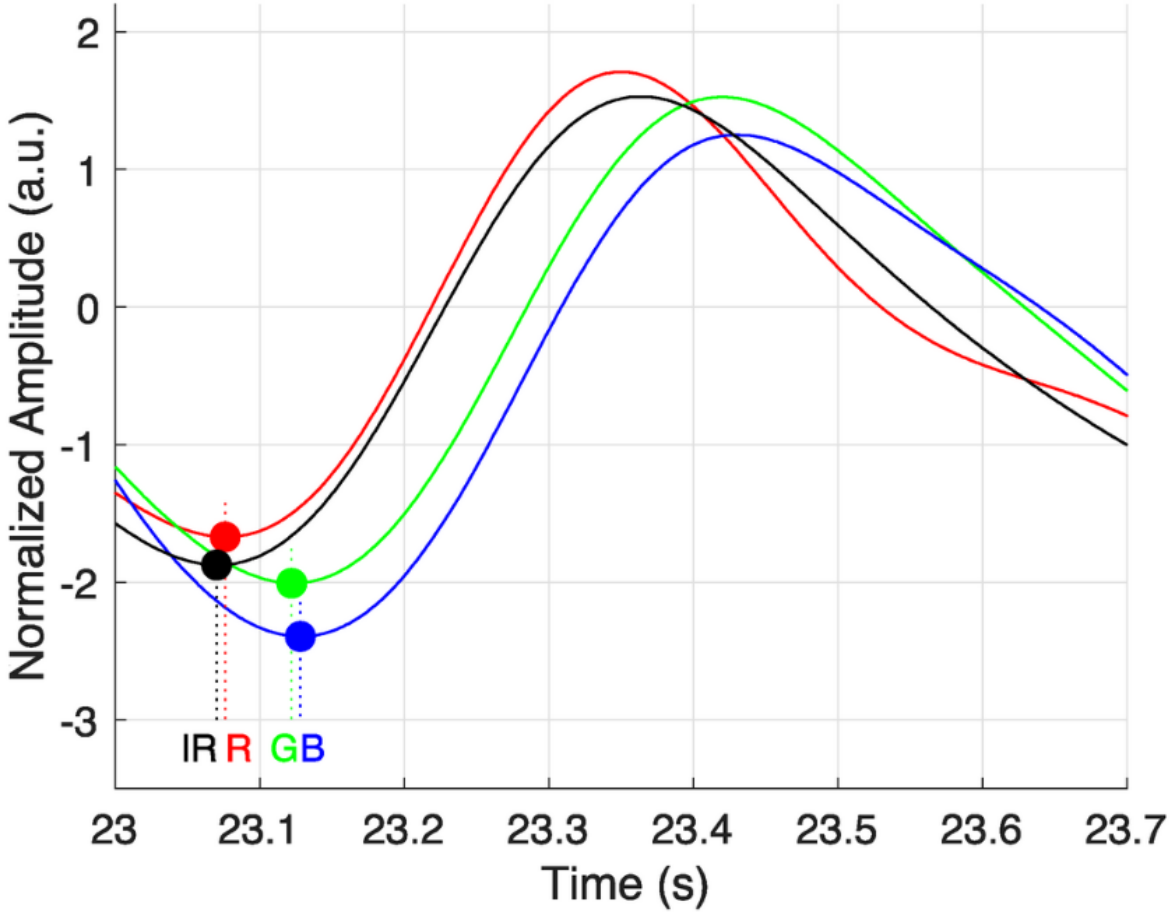
10.1007/s10877-019-00449-y



10.3390/s19245441

5.1.1 PPG signal (continued)

What wavelength to use?

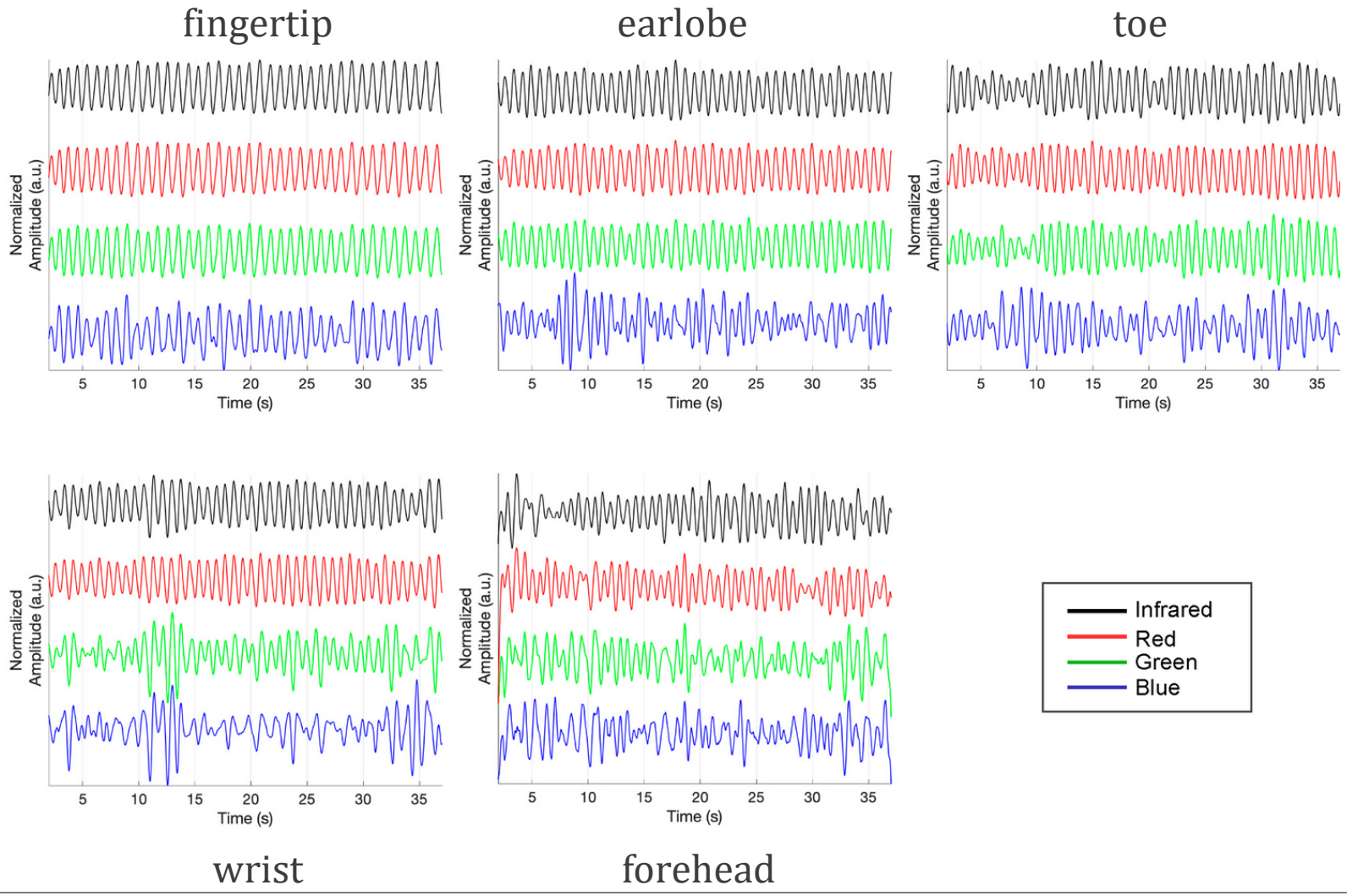


10.3390/s19245441

5.1.1 PPG signal (continued)

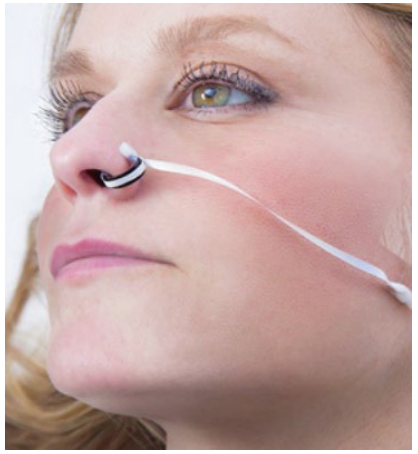
What wavelength to use?

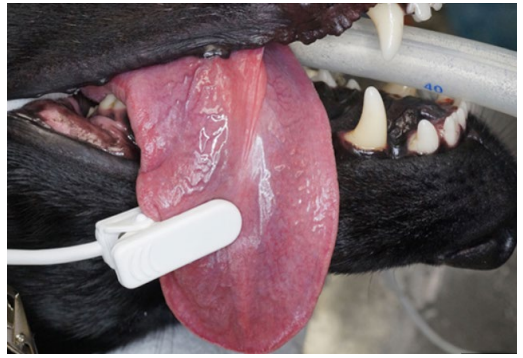
Where to measure?

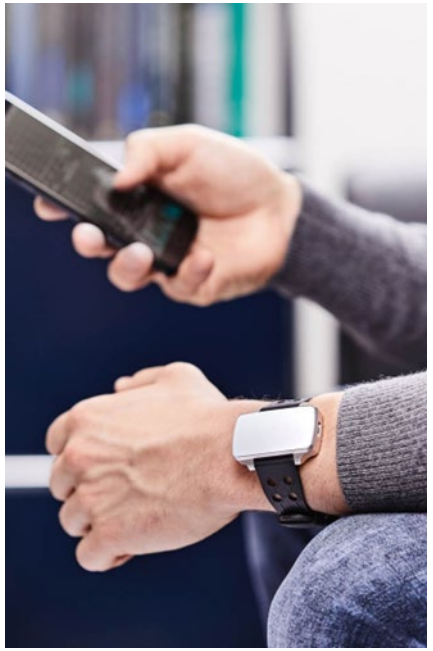


5.1.1 PPG signal (continued)

Where to measure?

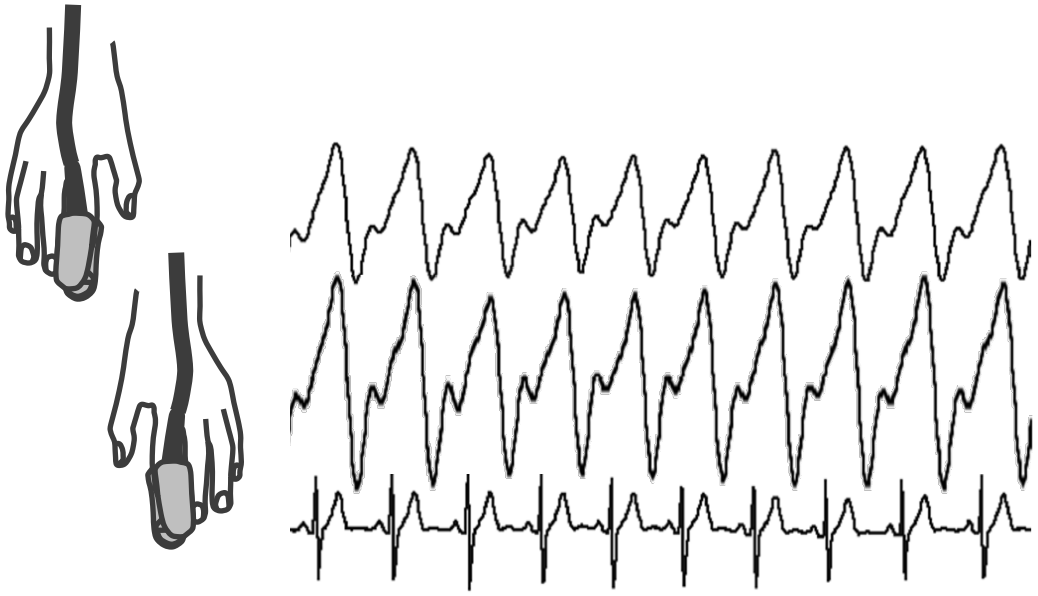






5.1.1 PPG signal (continued)

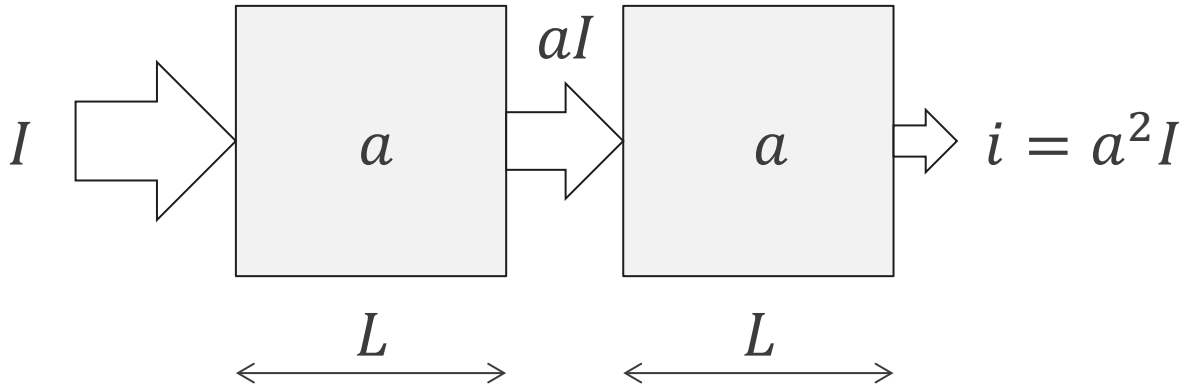
Vasocontriction



10.1088/1742-6596/450/1/012012

5.1.1 PPG signal (continued)

Beer-Lambert law



$$a = 10^{-\alpha L}$$

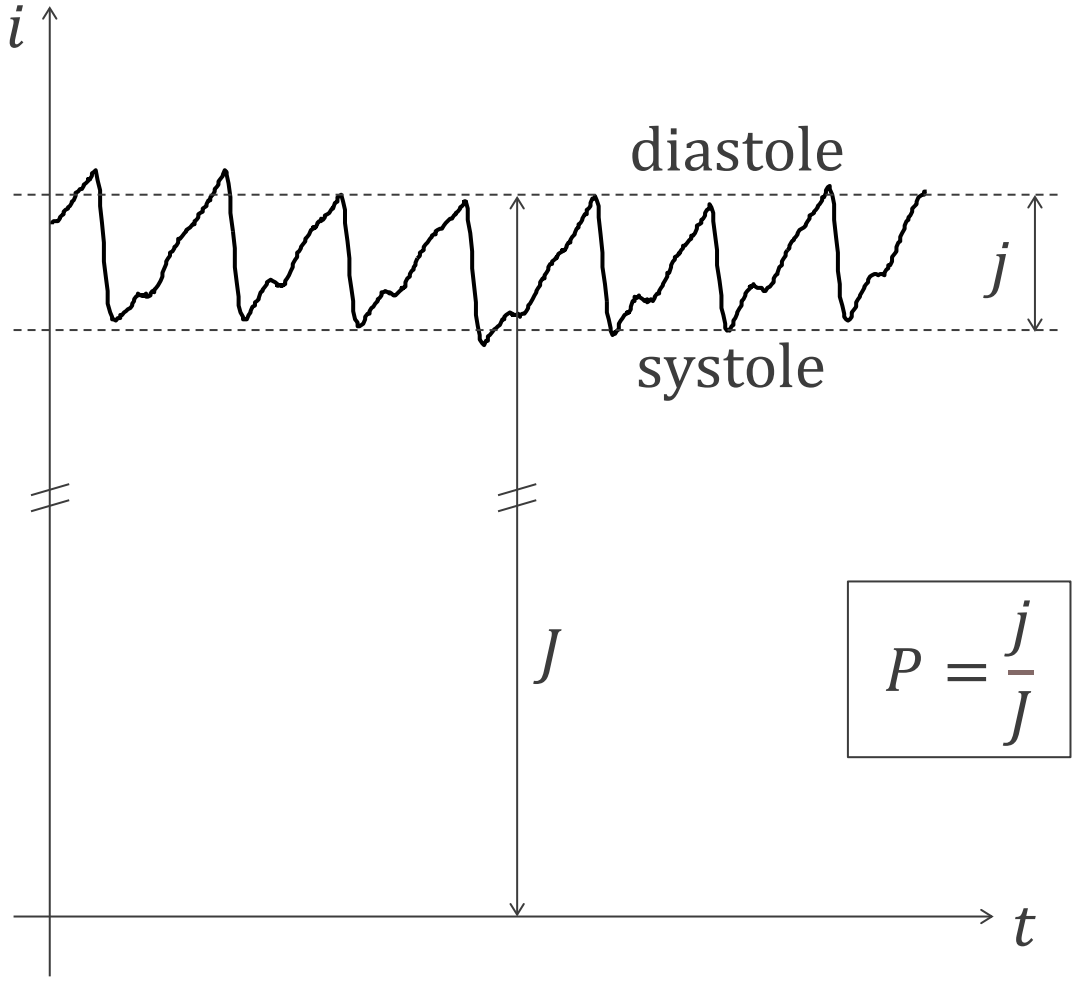
α: absorption coefficient (mm^{-1})

$$a = 10^{-\varepsilon c L}$$

ε: molar absorption coefficient ($\mathrm{mm}^{-1}/\mathrm{M}$)

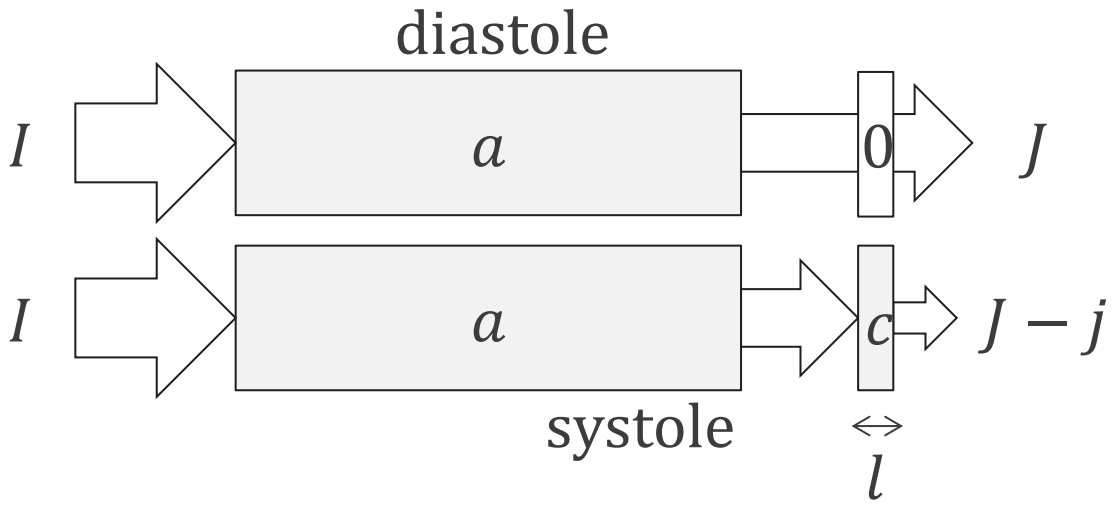
c: concentration (M)

5.1.1 PPG signal (continued)



$$P = \frac{j}{J}$$

perfusion



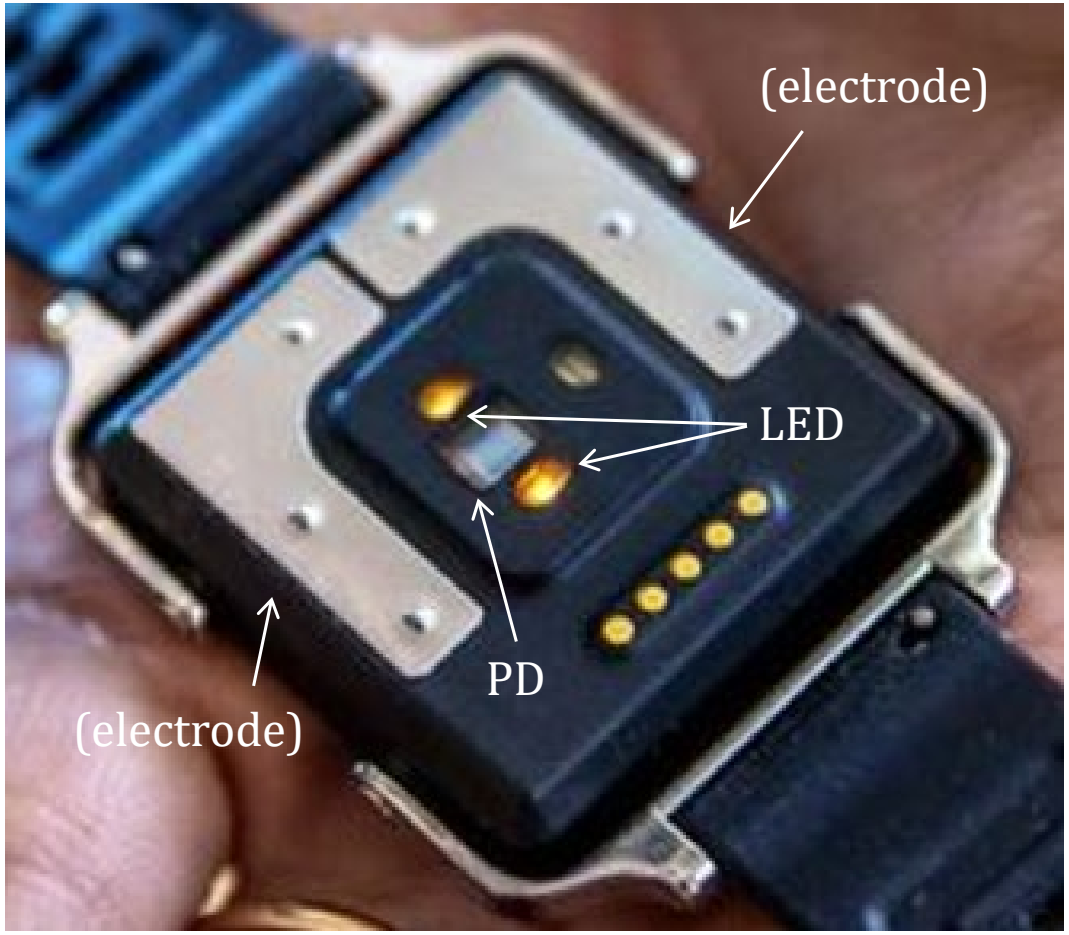
$$P = \frac{j}{J} = \frac{Ia\left(1 - 10^{-\varepsilon c l}\right)}{Ia} \simeq \ln 10 \cdot \varepsilon c l$$

$$L = \ln 10 \cdot l$$

$$P = \varepsilon c L$$

5.1.2 oHRM

wrist sensor



5.1.2 oHRM (continued)

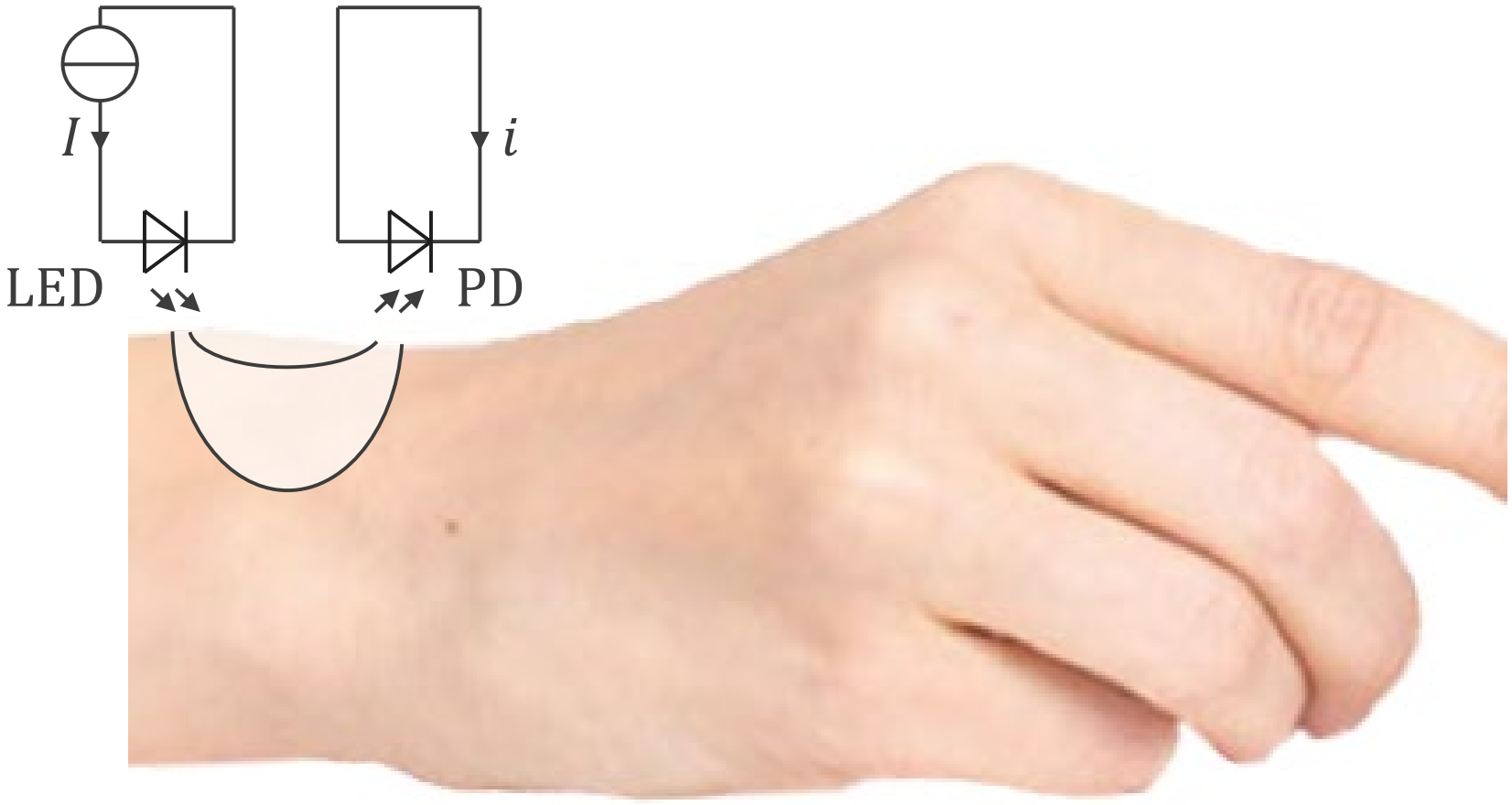
safety issue: burn

$T < 43\ °C$

(IEC 60601-1)

6.1.2 oHRM (continued)

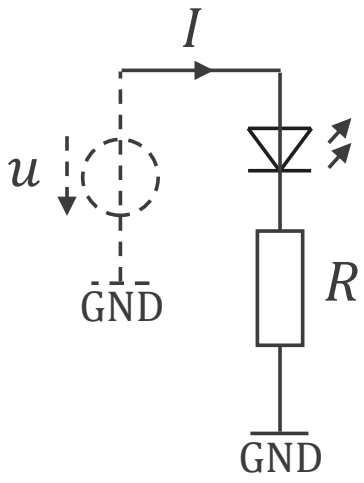
electronics (principle)



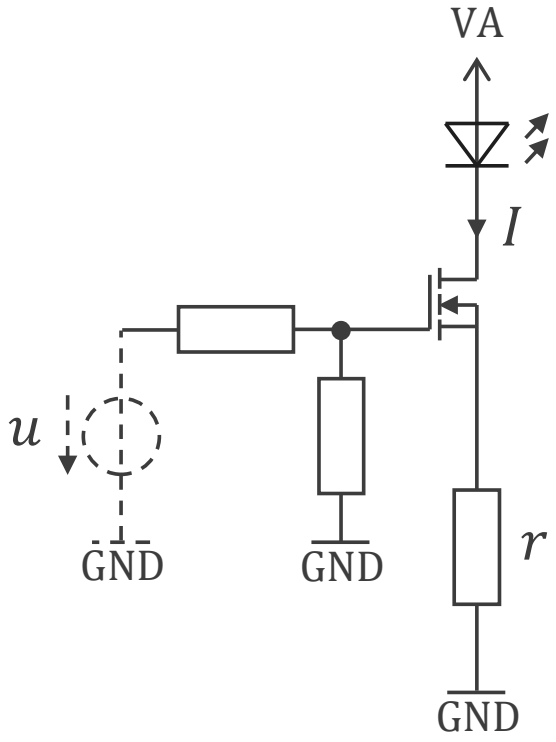
5.1.2 oHRM (continued)

LED driver

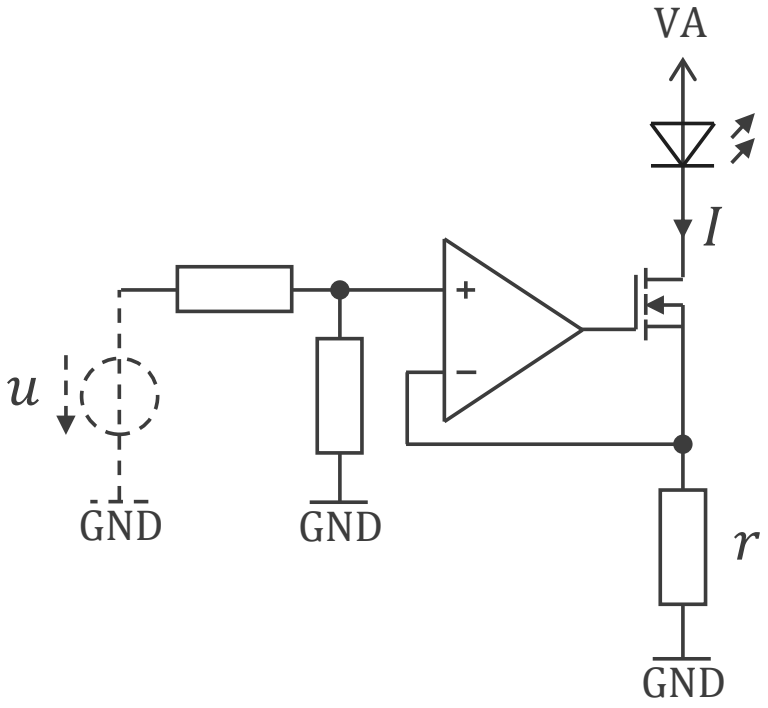
simplest



better

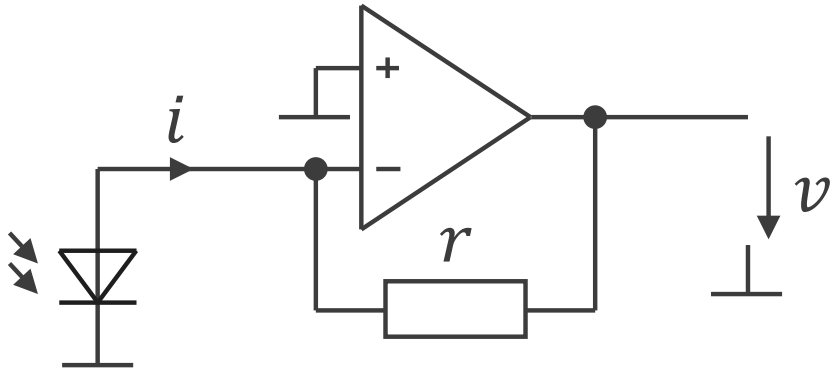


best current source



5.1.2 oHRM (continued)

PD amplifier

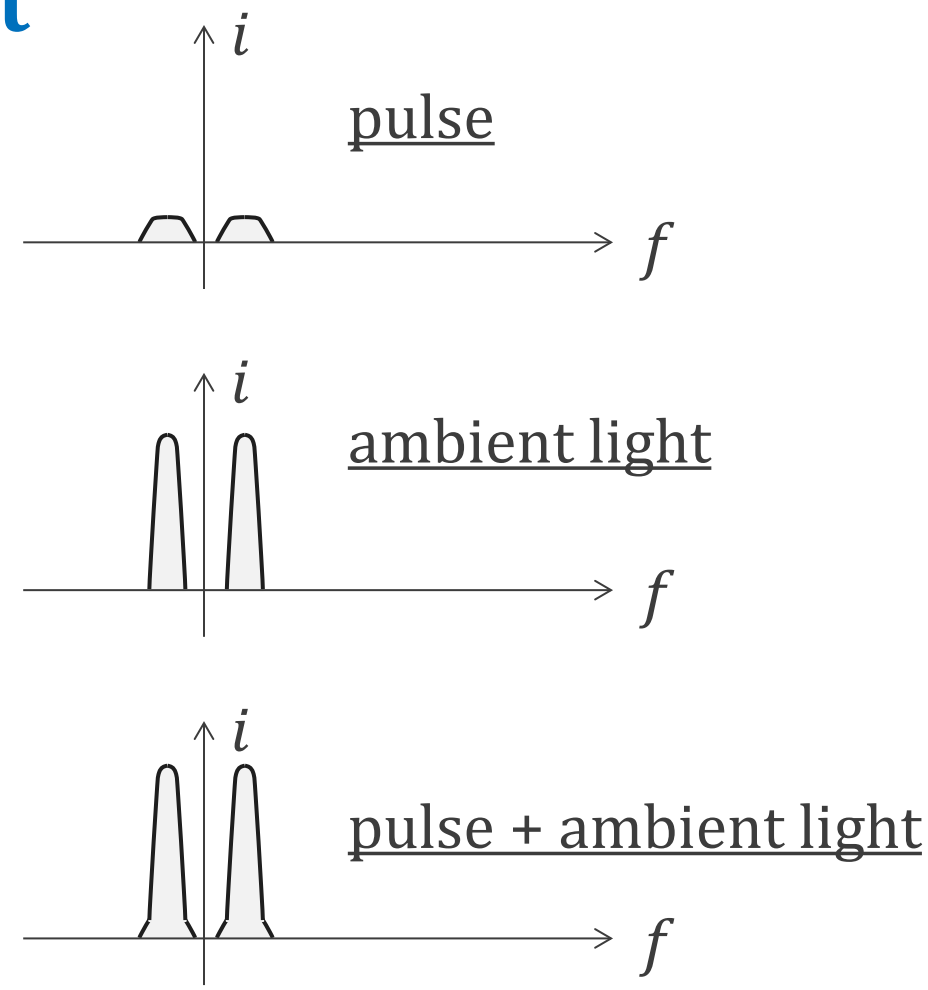


shot noise

$$\sigma_i^2 = 2qi \int_0^\infty |F(j2\pi f)|^2 df$$

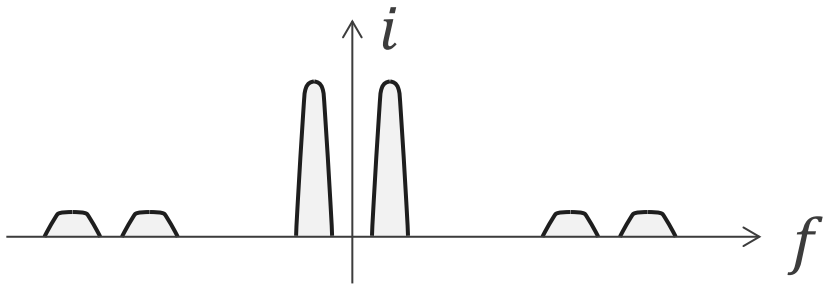
5.1.3 Ambient light

- fluorescent lighting
- running in the sun
- helicopter

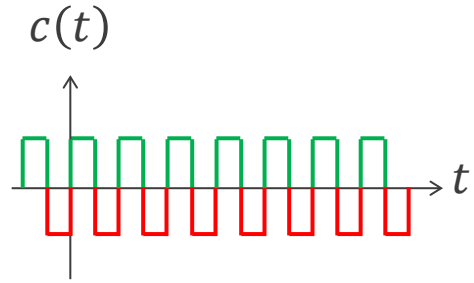


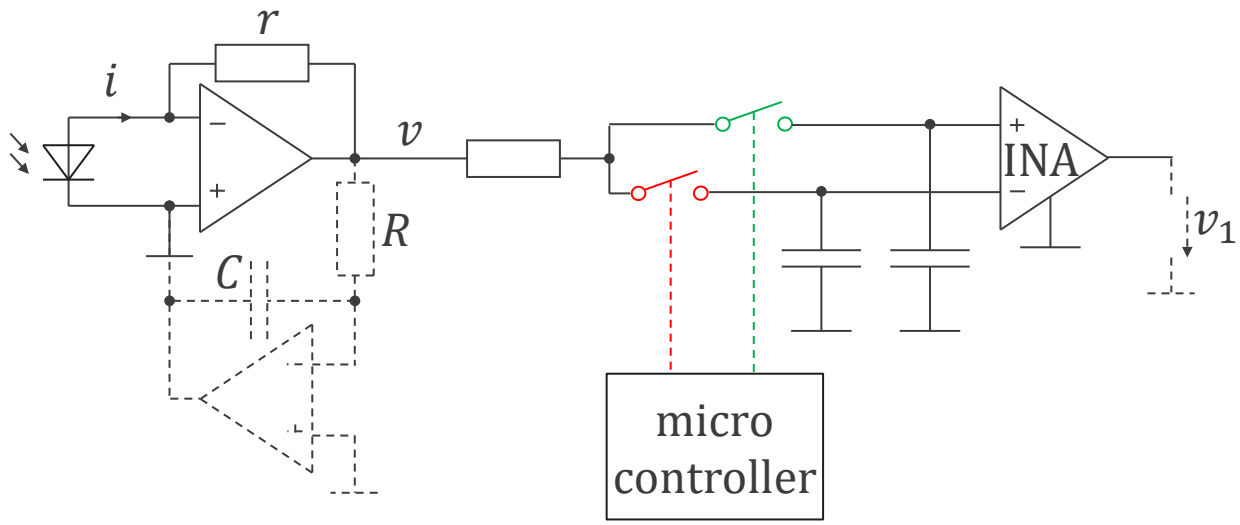
5.1.3 Ambient light (continued)

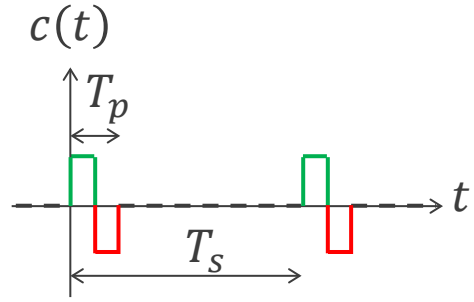
AM modulation/demodulation



$$I = I_0 \cos 2\pi f_c t$$

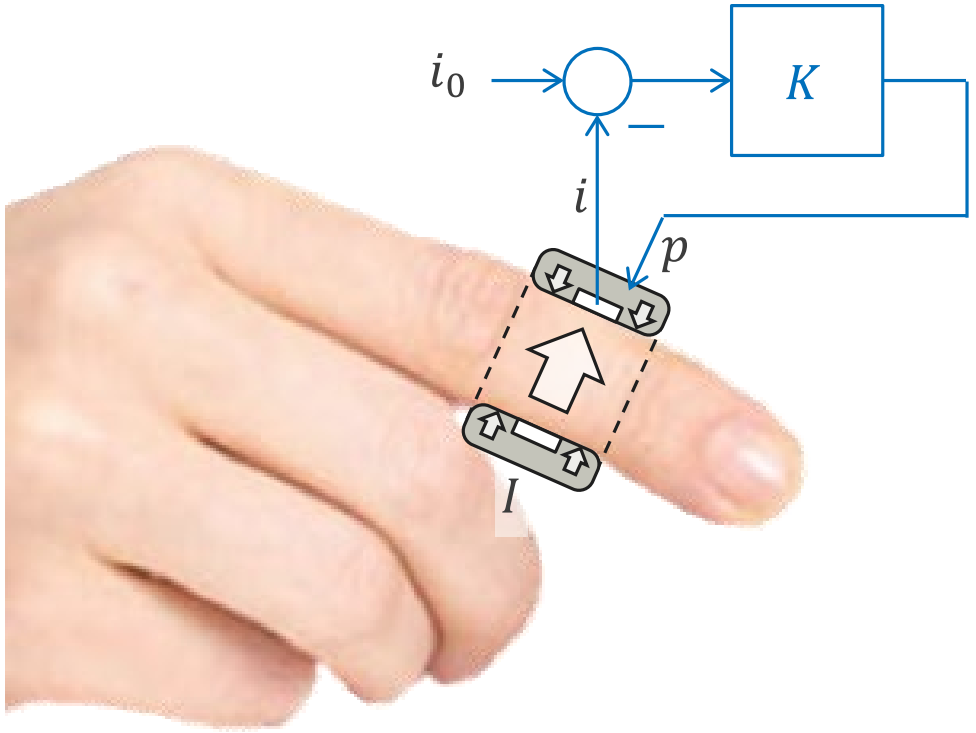


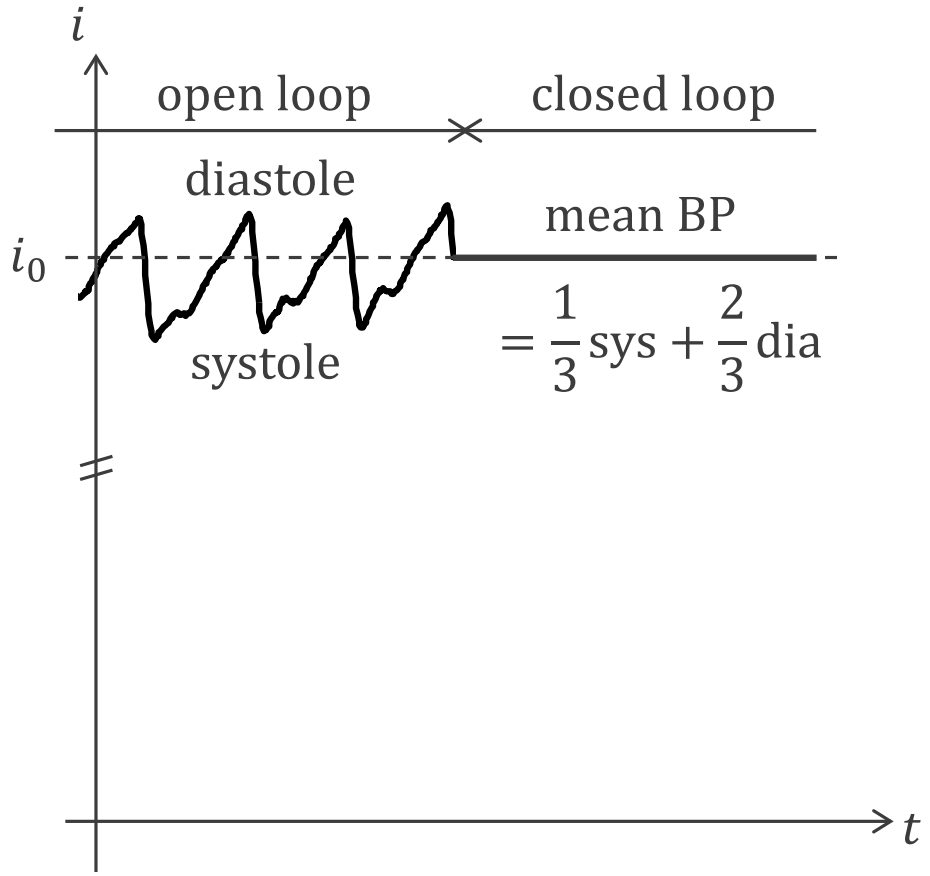




$$\text{SNR} = \frac{\sqrt{P}}{\sigma}\sqrt{\frac{T_s}{T_p}}$$

5.1.4 Volume clamp blood pressure

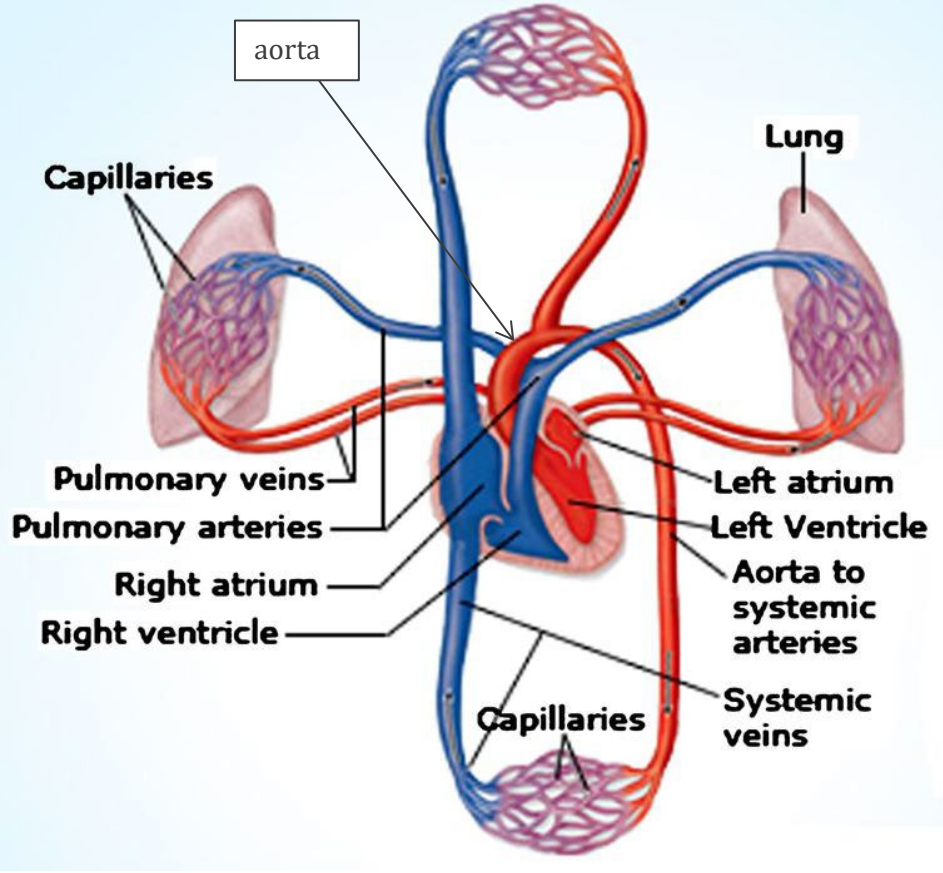


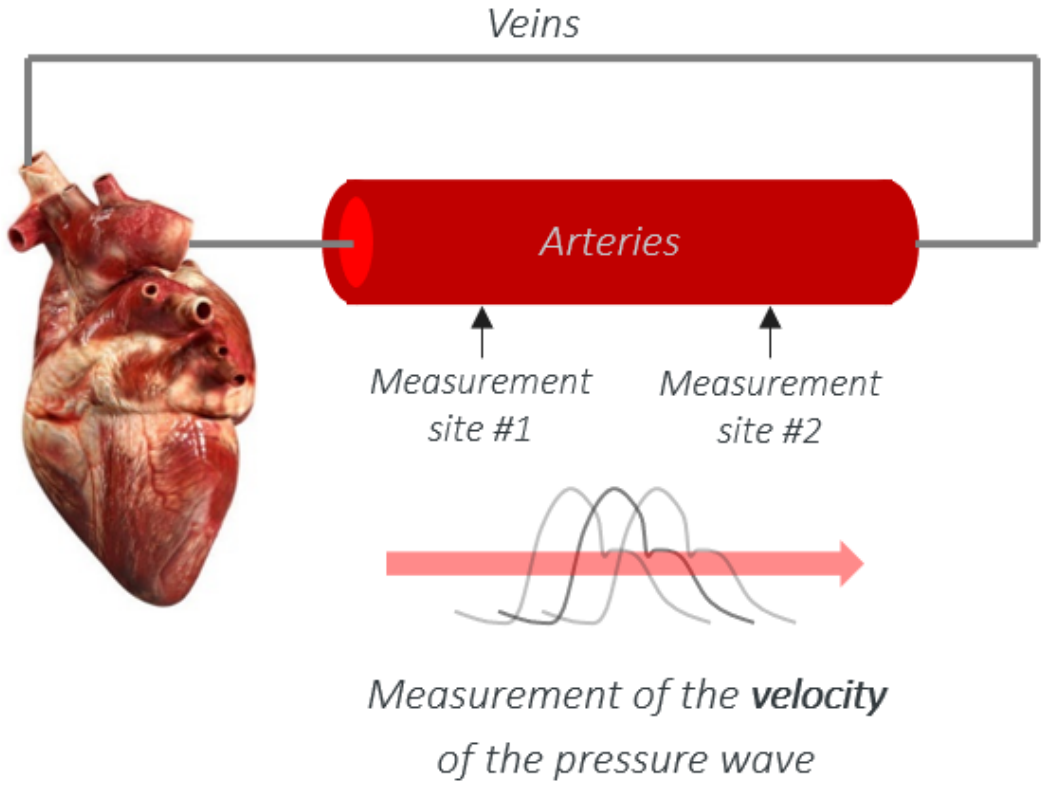


5.1.4 Volume clamp blood pressure (continued)

ISO 81060-3

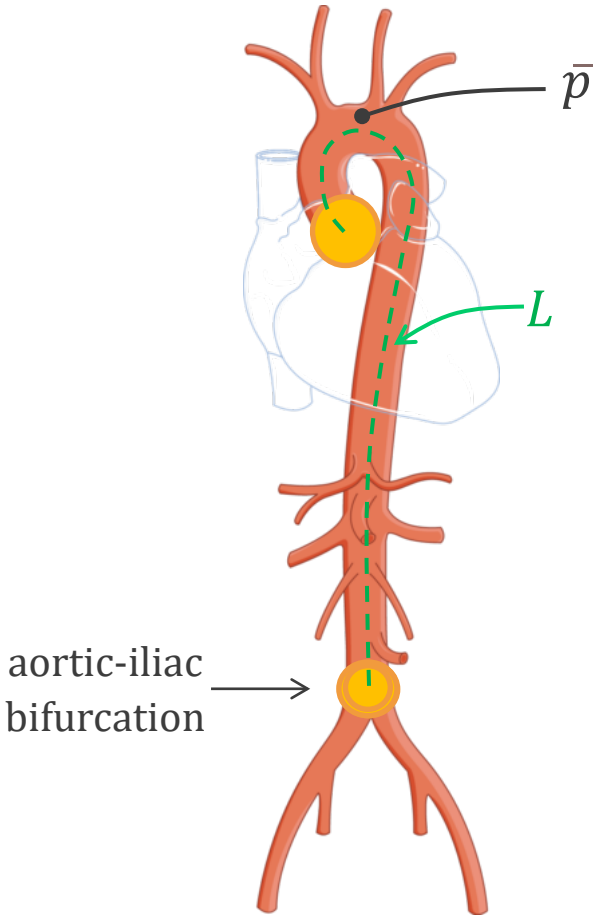
5.1.5 Optical blood pressure monitoring (oBPM®)

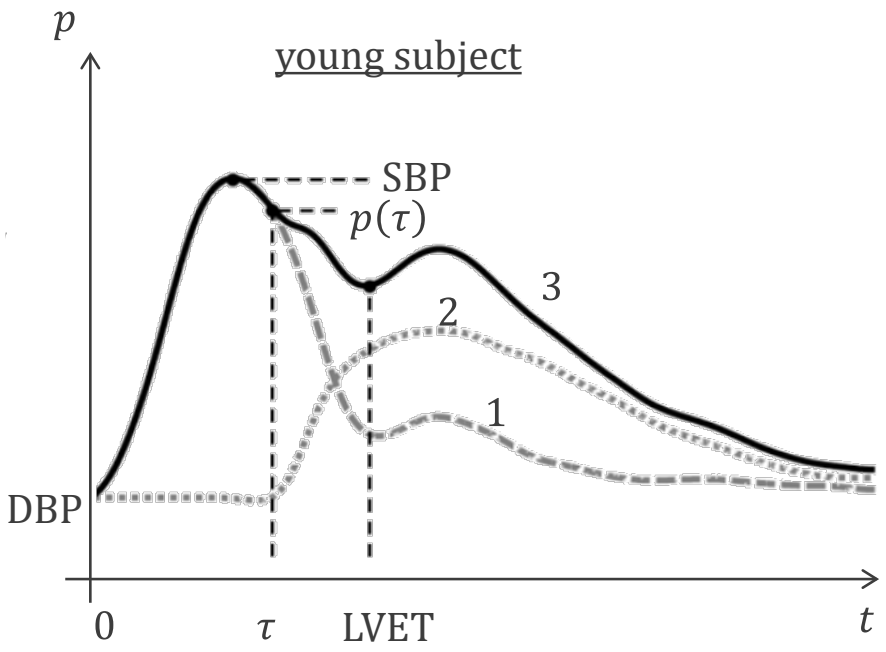




$$\mathrm{PWV} = 2\sqrt{\alpha\bar{p} + \beta}$$

5.1.5 oBPM® (continued)





$$\tau = \frac{L}{\sqrt{\alpha\bar{p} + \beta}}$$

$$\boxed{\bar{p} = f(\tau)}$$

5.1.5 oBPM® (continued)

Quiz

oHRM uses green LEDs because

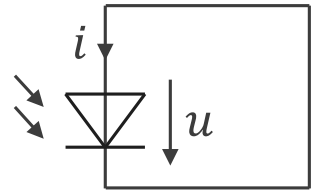
- ☐ they are the most efficient
- ☐ green is less absorbed by melanin
- ☐ PPG is less affected by motion
- ☐ green goes deeper into the tissue

Temperature T for APPLIED PART

- ☐ must be lower than 37 °C
- ☐ must be lower than 40 °C
- ☐ must be lower than 43 °C
- ☐ must be lower than 46 °C

Which is always correct?

- ☐ $u = 0, i = 0$
- ☐ $u > 0, i \geq 0$
- ☐ $u \leq 0, i > 0$
- ☐ $u = 0, i \leq 0$



Doubling the perfusion requires

- ☐ doubling the LED-PD distance
- ☐ squaring the LED-PD distance
- ☐ taking half of the LED-PD dist.
- ☐ taking the sqrt of LED-PD dist.

Vasocontriction results from

- ☐ exposure to high temperature
- ☐ exposure to low temperature
- ☐ intense effort
- ☐ sweating