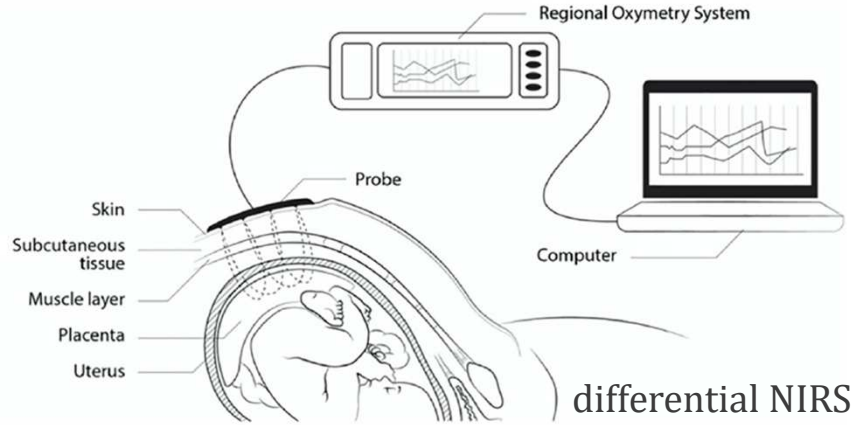
EE-511 Sensors in medical instrumentation
Chapter 5 – SpO2 and NIRS (continued)

SpO2

NIRS

NIRS

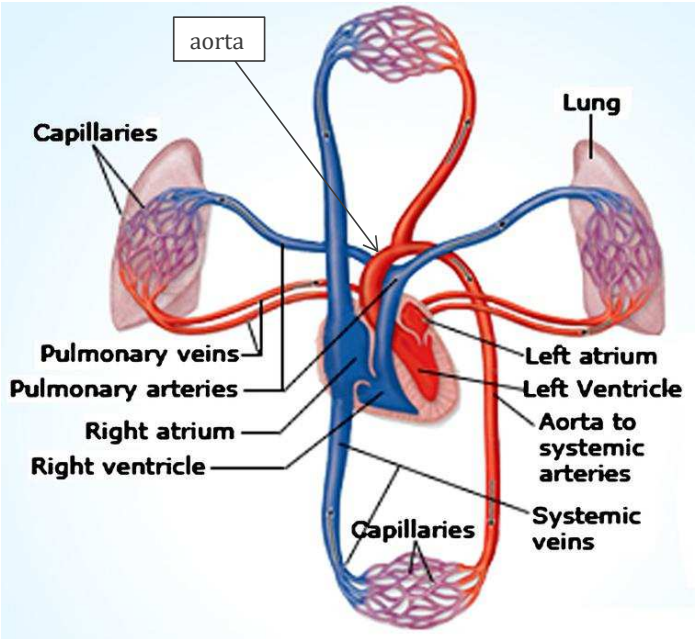


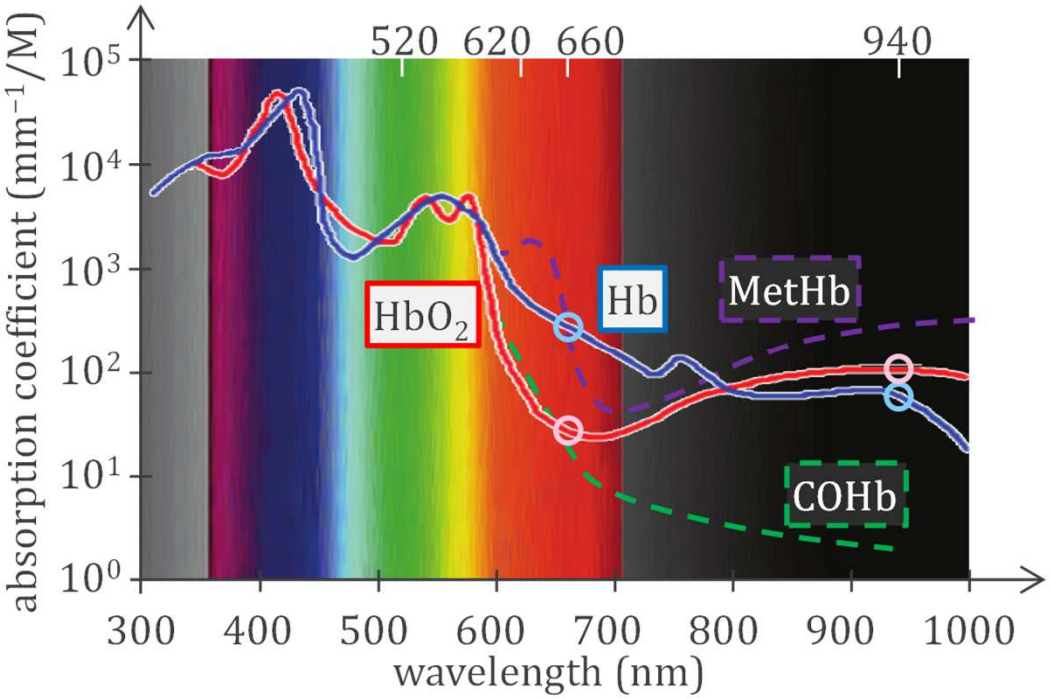
differential NIRS

5.1.6 SpO2

$$SaO2 = \frac{[HbO2]}{[Hb] + [HbO2]} \cdot 100\%$$

HbO2: *oxyhemoglobin* (red)
Hb: *deoxyhemoglobin* ('blue')

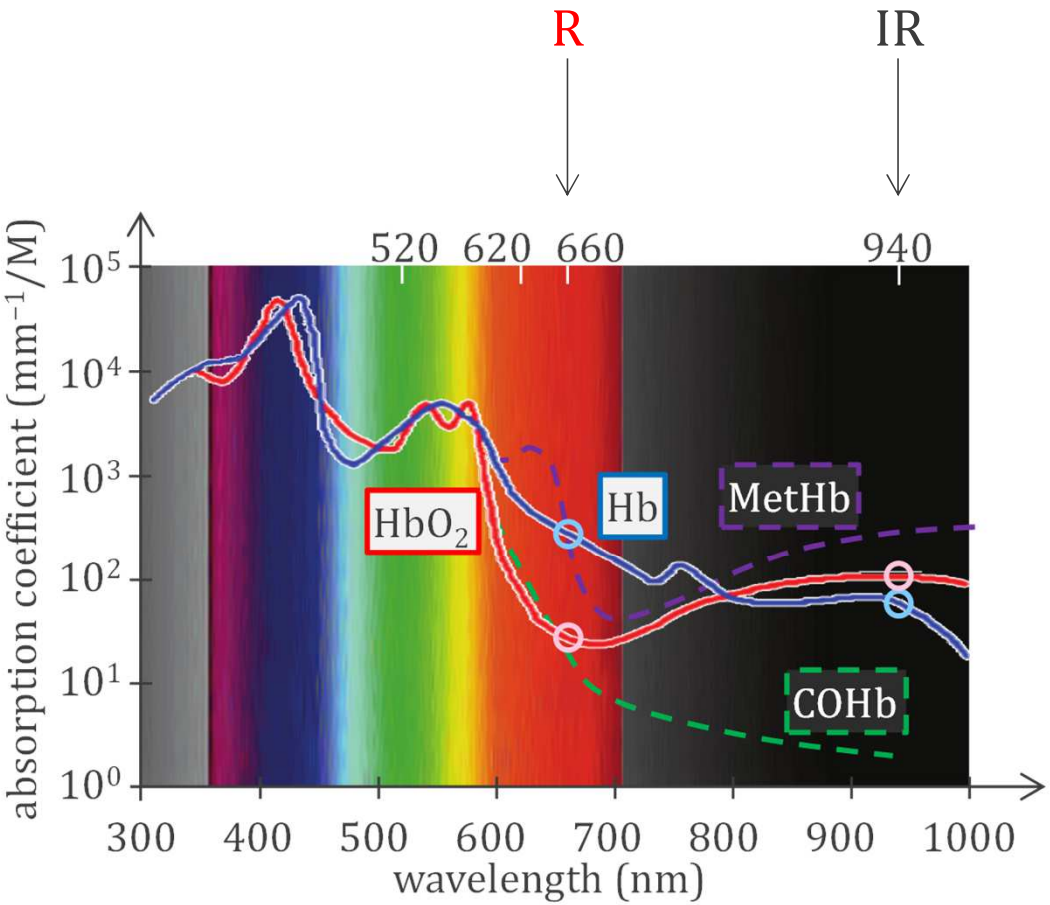




5.1.6 SpO2 (continued)

$$P^{R} = L^{R}\left(\varepsilon^{R}_{HbO2}[HbO2] + \varepsilon^{R}_{Hb}[Hb]\right)$$

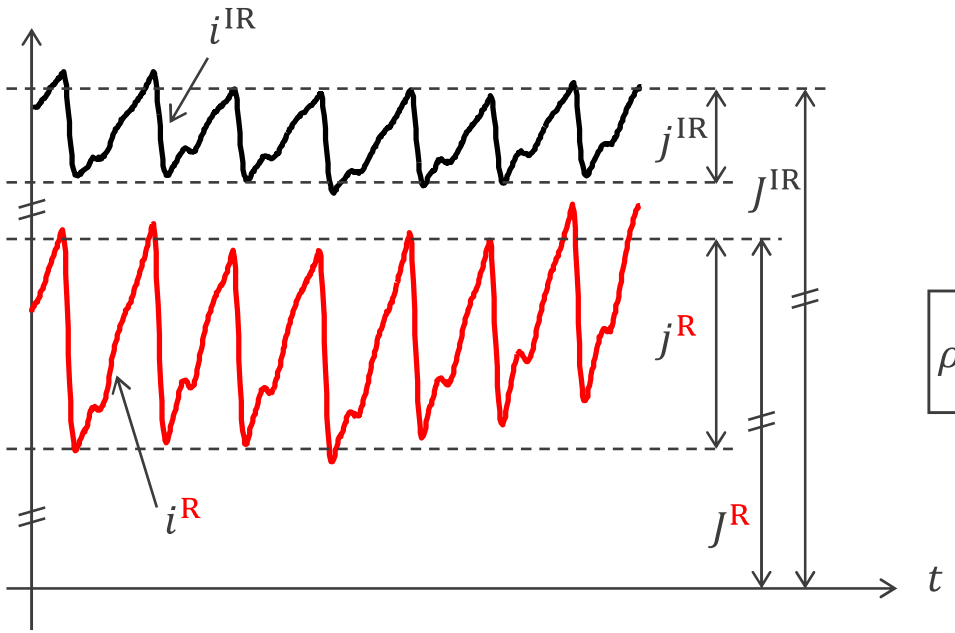
$$P^{IR} = L^{IR}\left(\varepsilon^{IR}_{HbO2}[HbO2] + \varepsilon^{IR}_{Hb}[Hb]\right)$$



5.1.6 SpO2 (continued)

ratio of ratios

$$\rho = \frac{P^{\mathrm{R}}}{P^{\mathrm{IR}}}$$

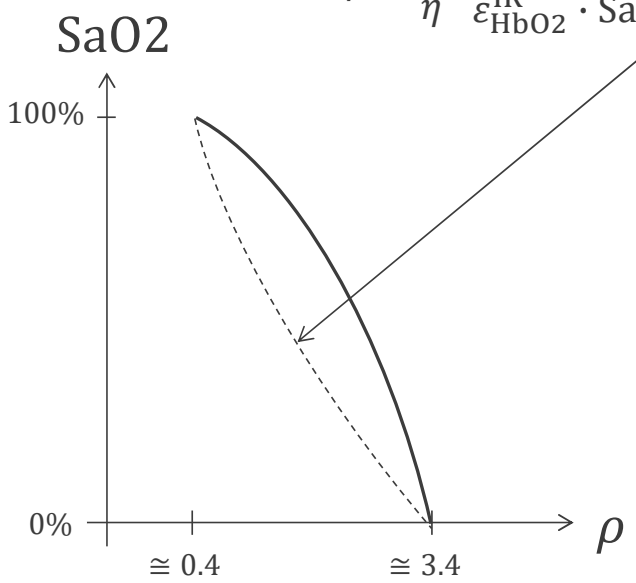


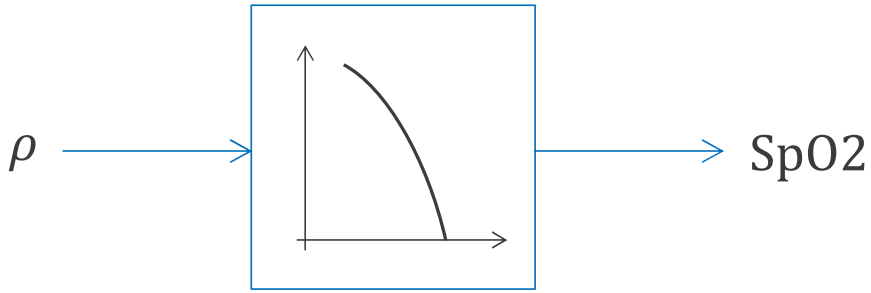
$$\rho = \frac{j^{\mathrm{R}}/J^{\mathrm{R}}}{j^{\mathrm{IR}}/J^{\mathrm{IR}}}$$

6.1.6 SpO2 (continued)

SpO2 instead of SaO2

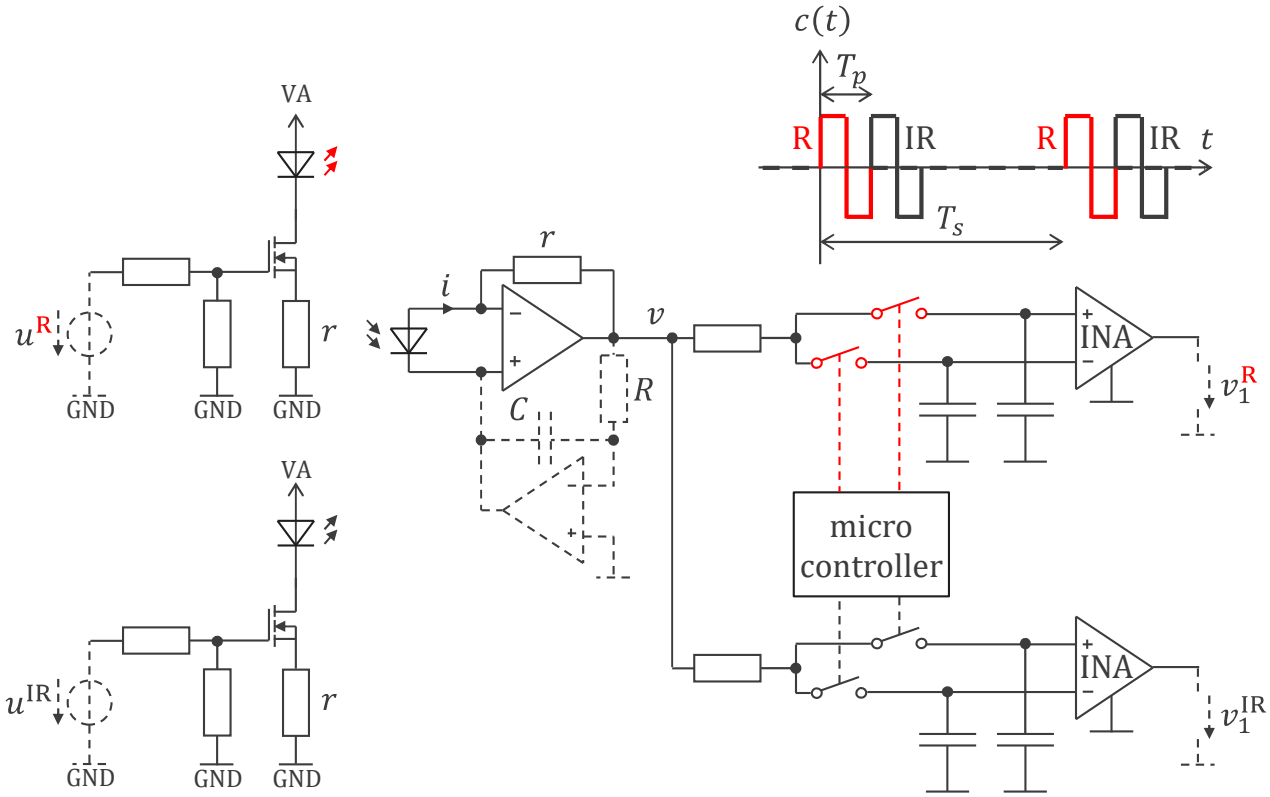
$$\rho = \frac{1}{\eta} \cdot \frac{\varepsilon^{R}_{HbO2} \cdot SaO2 + \varepsilon^{R}_{Hb} \cdot (1 - SaO2 + v)}{\varepsilon^{IR}_{HbO2} \cdot SaO2 + \varepsilon^{IR}_{Hb} \cdot (1 - SaO2 + v)}$$





5.1.6 SpO2 (continued)

circuit



5.2.1 Basic NIRS

usage

- near infrared range: 690–850 nm
- StO2 (tissue oxygen saturation)
- StO2 = [HbO2] / ([Hb]+[HbO2])
- regional oxygenation
- brain, muscle, etc.

5.2.1 Basic NIRS (continued)

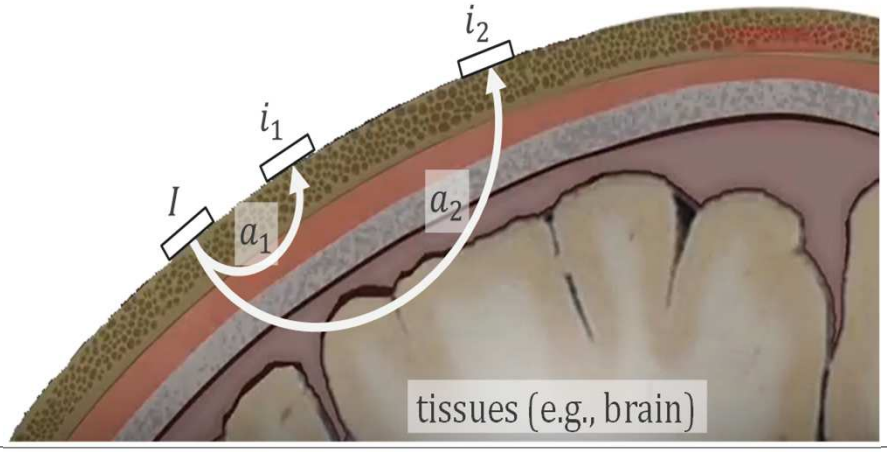
principle

- pulsatility of SpO2 replaced by shallow detector 1
- Beer-Lambert law more difficult to justify $i \cong Ie^{\varepsilon c \bar{L}}$

$$\ln i_k^{\mathrm{R}} = \ln I^{\mathrm{R}} + \bar{L}_k^{\mathrm{R}}\left(\varepsilon_{\mathrm{HbO2}}^{\mathrm{R}}[\mathrm{HbO2}] + \varepsilon_{\mathrm{Hb}}^{\mathrm{R}}[\mathrm{Hb}]\right)$$

$$\ln i_k^{\mathrm{IR}} = \ln I^{\mathrm{IR}} + \bar{L}_k^{\mathrm{IR}}\left(\varepsilon_{\mathrm{HbO2}}^{\mathrm{IR}}[\mathrm{HbO2}] + \varepsilon_{\mathrm{Hb}}^{\mathrm{IR}}[\mathrm{Hb}]\right)$$

$$\rho = \frac{\ln i_2^{\mathrm{R}} - \ln i_1^{\mathrm{R}}}{\ln i_2^{\mathrm{IR}} - \ln i_1^{\mathrm{IR}}} = \frac{\ln\left(i_2^{\mathrm{R}}/i_1^{\mathrm{R}}\right)}{\ln\left(i_2^{\mathrm{IR}}/i_1^{\mathrm{IR}}\right)}$$

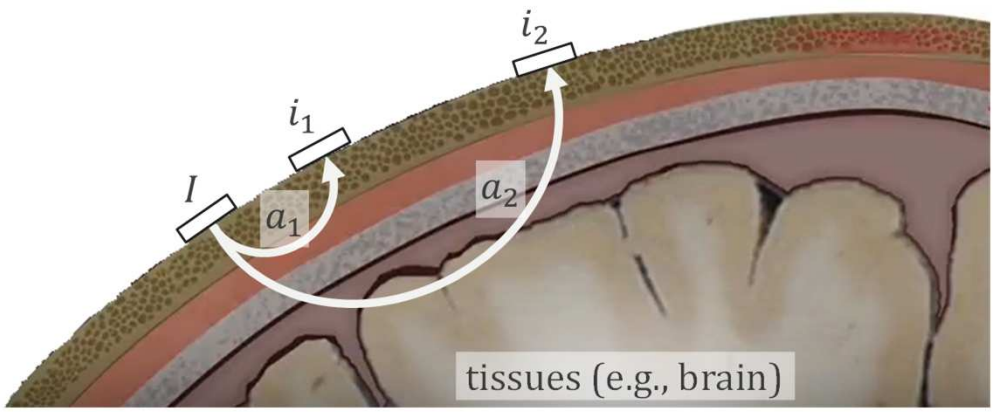


$$\rho = \frac{1}{\eta} \cdot \frac{\varepsilon_{\mathrm{HbO2}}^{\mathrm{R}} \cdot \mathrm{StO2} + \varepsilon_{\mathrm{Hb}}^{\mathrm{R}} \cdot (1 - \mathrm{StO2} + v)}{\varepsilon_{\mathrm{HbO2}}^{\mathrm{IR}} \cdot \mathrm{StO2} + \varepsilon_{\mathrm{Hb}}^{\mathrm{IR}} \cdot (1 - \mathrm{StO2} + v)}$$

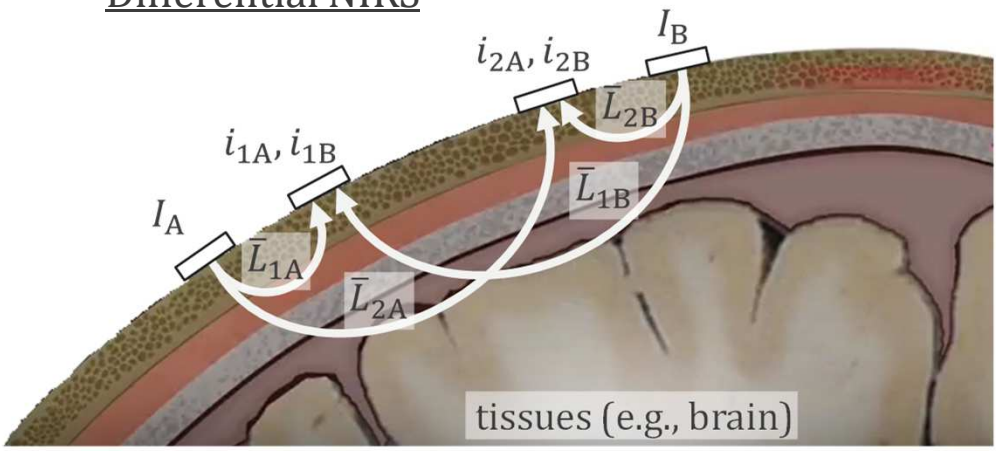
$$\mathrm{StO2} = f(\rho)$$

5.2.2 Differential NIRS

Basic NIRS



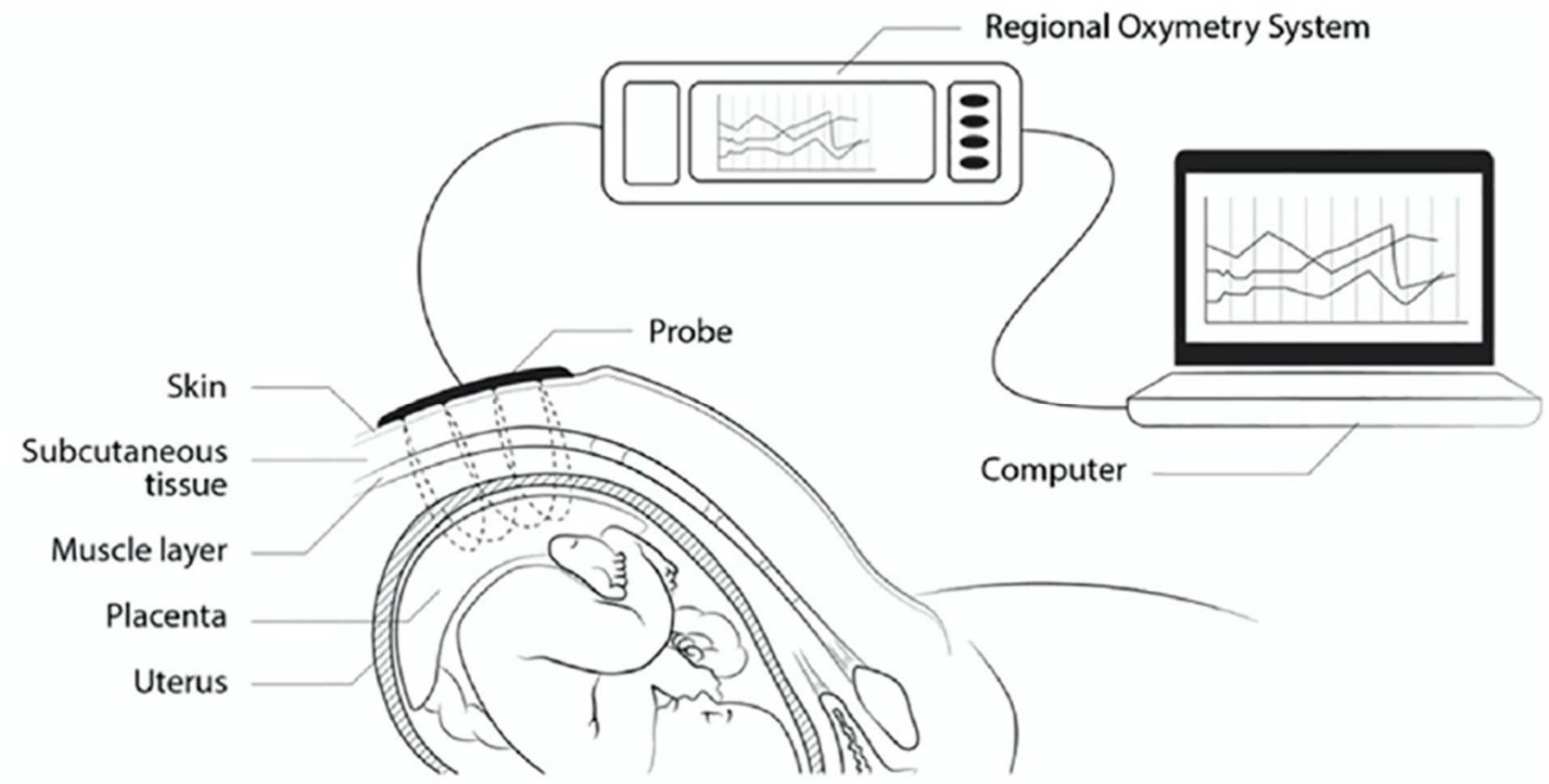
Differential NIRS



$$\rho = \frac{\ln \frac{i_2^R / g_2^R}{i_1^R / g_1^R}}{\ln \frac{i_2^{IR} / g_2^{IR}}{i_1^{IR} / g_1^{IR}}}$$

$$\rho = \frac{\ln \left(\frac{i_{2A}^R / g_2^R}{i_{1A}^R / g_1^R} \cdot \frac{i_{1B}^R / g_1^R}{i_{2B}^R / g_2^R} \right)}{\ln \left(\frac{i_{2A}^{IR} / g_2^{IR}}{i_{1A}^{IR} / g_1^{IR}} \cdot \frac{i_{1B}^{IR} / g_1^{IR}}{i_{2B}^{IR} / g_2^{IR}} \right)} = \frac{\ln \left(\frac{i_{2A}^R}{i_{1A}^R} \cdot \frac{i_{1B}^R}{i_{2B}^R} \right)}{\ln \left(\frac{i_{2A}^{IR}}{i_{1A}^{IR}} \cdot \frac{i_{1B}^{IR}}{i_{2B}^{IR}} \right)}$$

5.2.2 Differential NIRS (continued)



5.2.2 Differential NIRS (continued)