# 應用自動平衡橋於電阻抗法凝血時間檢測之電路設計與實現

# Auto-Balance Bridge Circuit of Electrical Impedance Method for Blood Coagulation Detection

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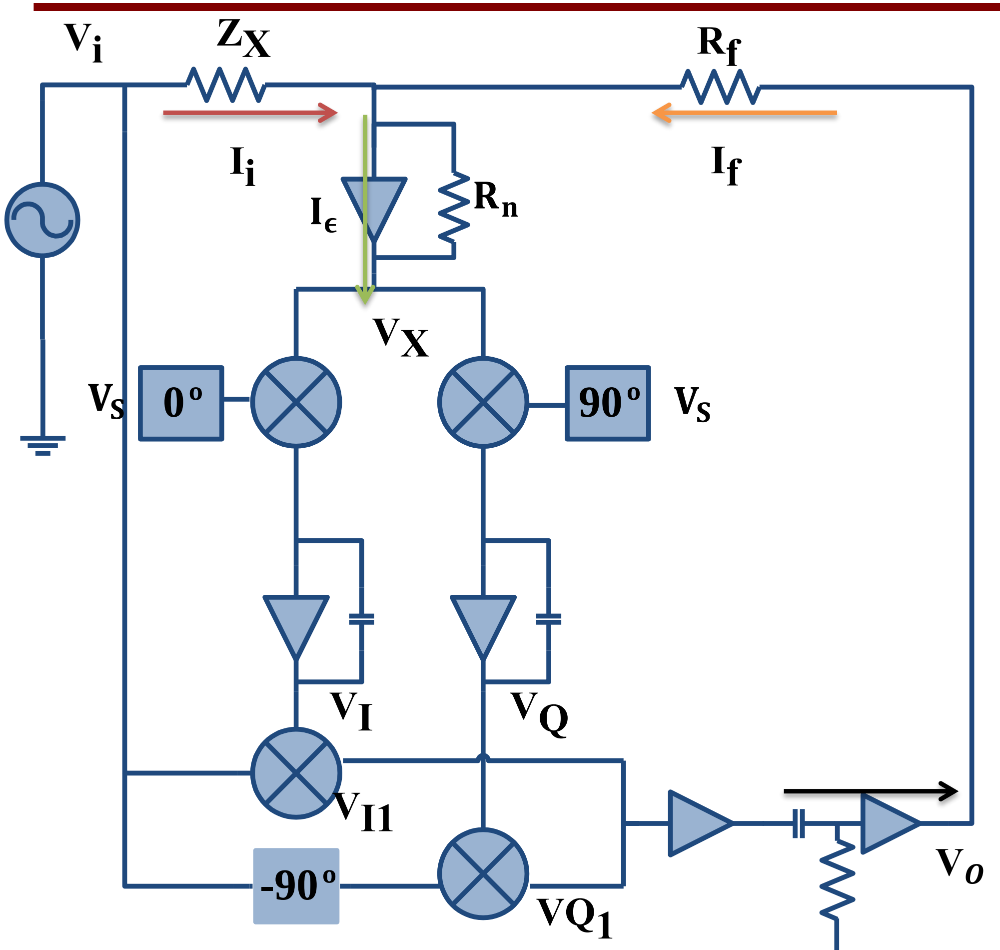
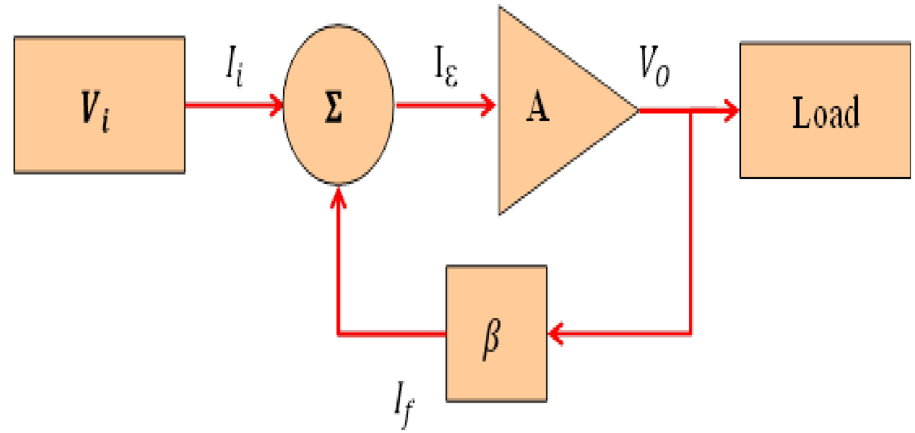
# Auto Balance Bridge Principle




$$Z_X = \frac{V_i}{I_i} = R_f \times \frac{V_i}{V_o} \quad \text{Phase} = \frac{(t_{Vi} - t_{Vo})}{\frac{1}{f}} \text{-}180^\circ$$

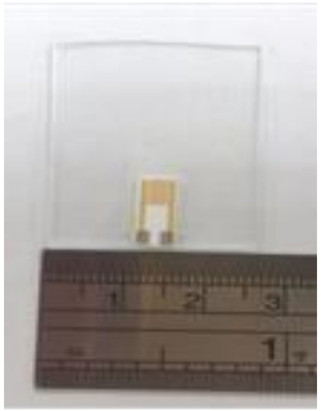
$$Z_X' = {}^{V_i}\Big/_{(I_\varepsilon + \frac{V_o}{R_f})} \qquad \text{A} = \frac{V_o}{I_\varepsilon} \text{、} \beta = \frac{1}{R_f}$$

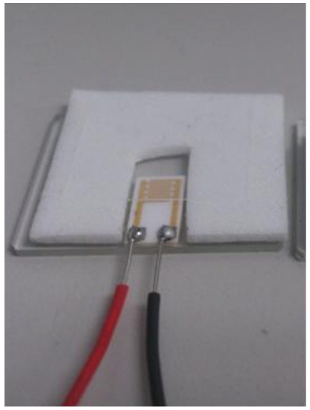
$$\text{Loop Gain} = \frac{V_o}{I_\varepsilon} \times \frac{1}{R_f}$$

$$E = ({}^{Z_X - Z_X'}/_{Z_X}) \times 100\% \Rightarrow E = (\frac{R_f \times I_\varepsilon}{V_o + R_f \times I_\varepsilon}) \times 100\% \Rightarrow E = (\frac{1}{\frac{V_o}{I_\varepsilon} \times \frac{1}{R_f} + 1}) \times 100\%$$

- Loop Gain 的大小與量測誤差成反比

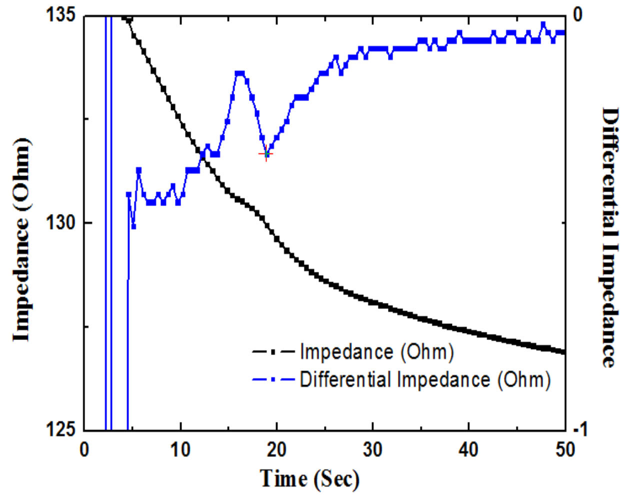
# Experiment Setup and Results



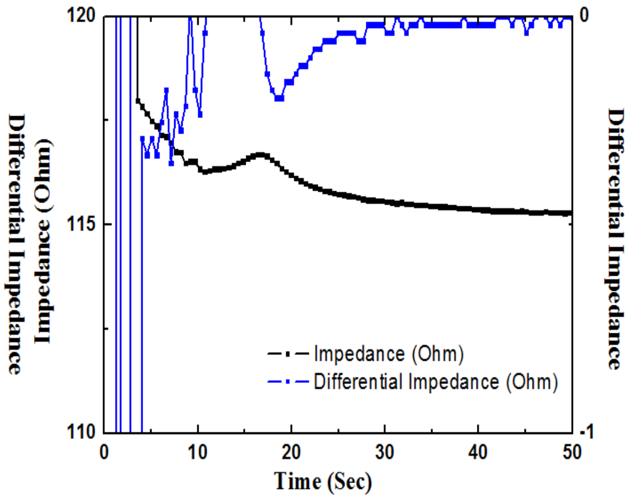


- 使用金電極(Au4405A)、銀電極(D-5670)佈在氧化二鋁上所組成的電極
- 泡棉膠貼置載玻片其他區域，使血液可以固定

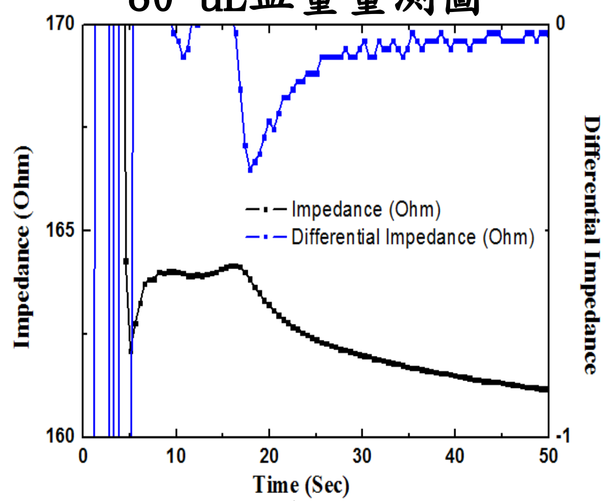
血量較小造成的凝血阻抗變化更明顯



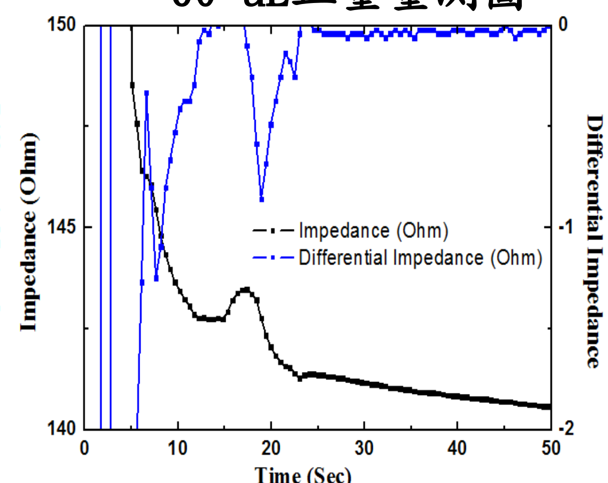

80 uL血量量測圖




60 uL血量量測圖

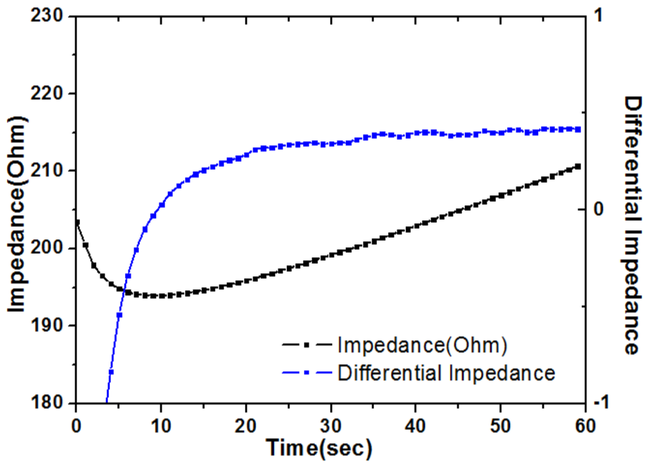



40 uL血量量測圖

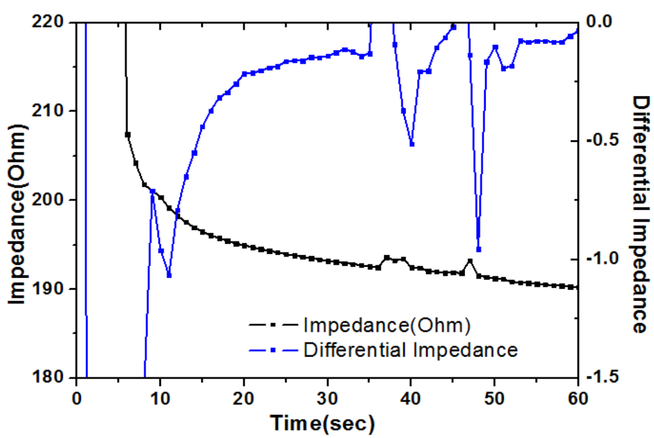



20 uL血量量測圖

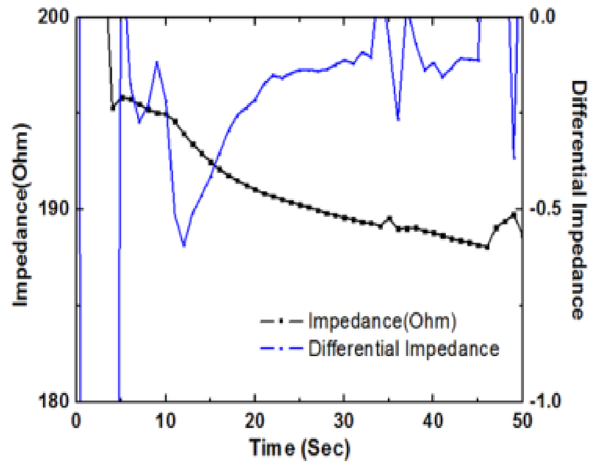
# Auto Balance Bridge Results

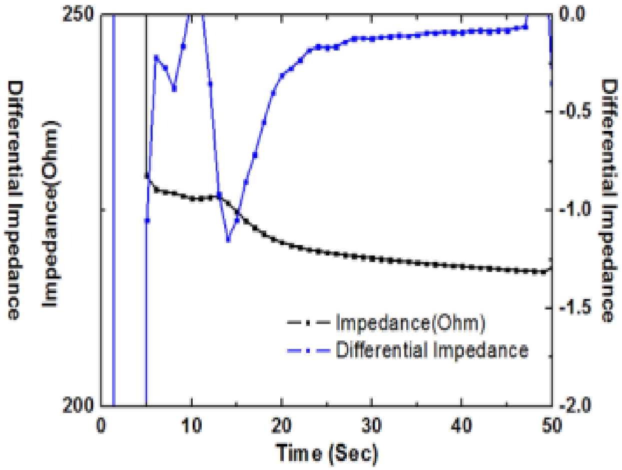



無凝血

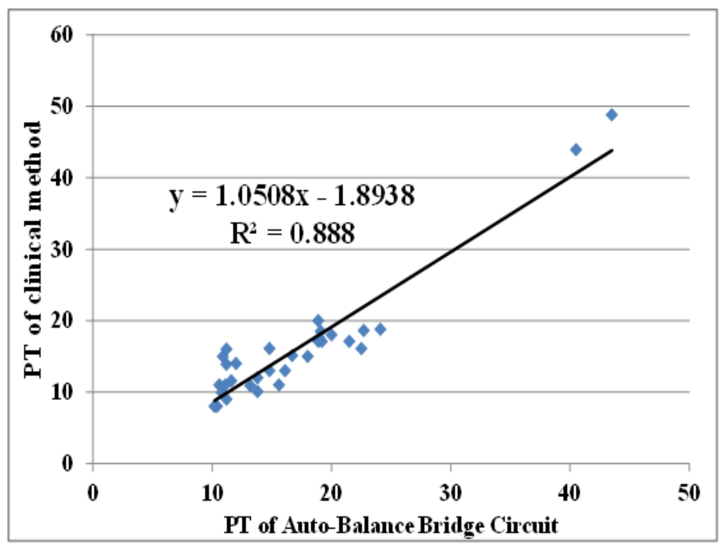



凝血



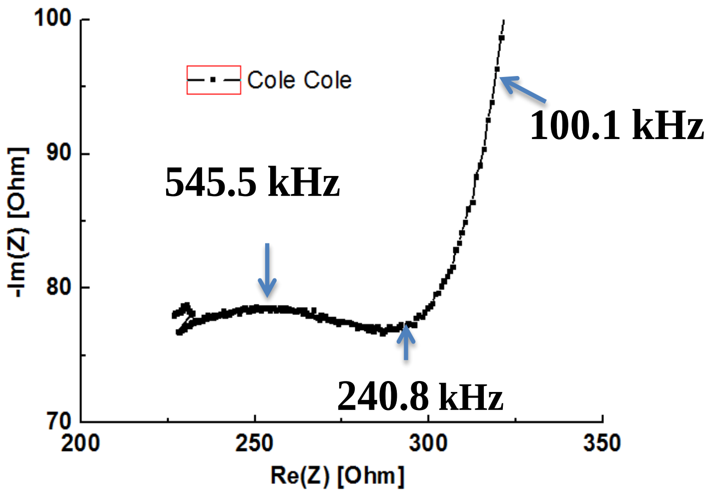




以一階微分最小值判別阻抗變化最劇烈的時間點

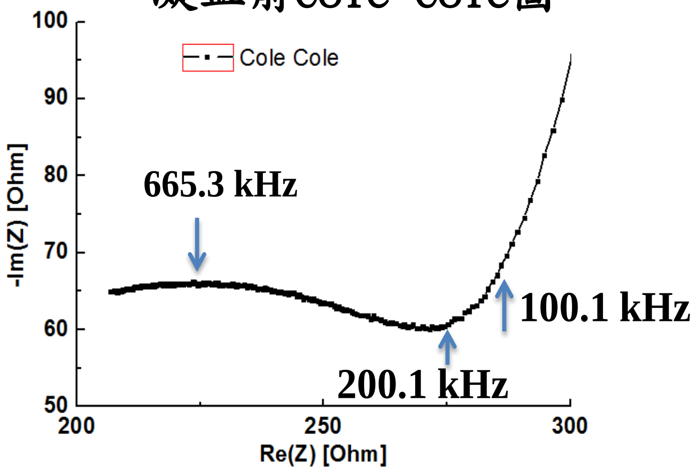



量測凝血時間與手撈時間變化相關係數可達0.888

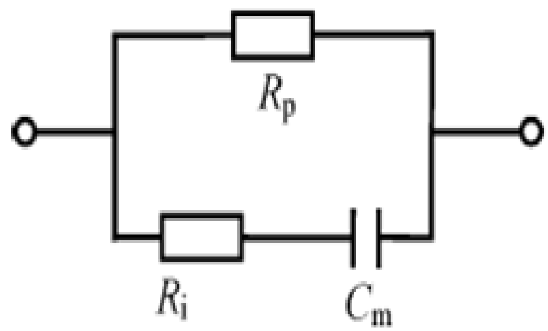
# Auto Balance Bridge Results




凝血前Cole-Cole圖




凝血後Cole-Cole圖




$R_p$ = 血漿內阻

$R_i$ = 血液細胞內阻

$C_m$= 血液細胞膜

**低頻血液模型參數表**

| | $R_p$ | $R_i$ | $C_m$ |
|---|---|---|---|
| 凝血前 | 405.6 Ω | 12.11 kΩ | 1.64 nF |
| 凝血後 | 322.1 Ω | 756.7 Ω | 0.33 nF |

**特徵頻率血液模型參數表**

| | $R_p$ | $R_i$ | $C_m$ |
|---|---|---|---|
| 凝血前 | 337.6 Ω | 14.48 kΩ | 1.38 nF |
| 凝血後 | 285.7 Ω | 678.2 Ω | 0.32 nF |