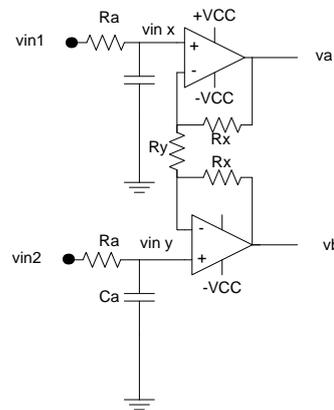
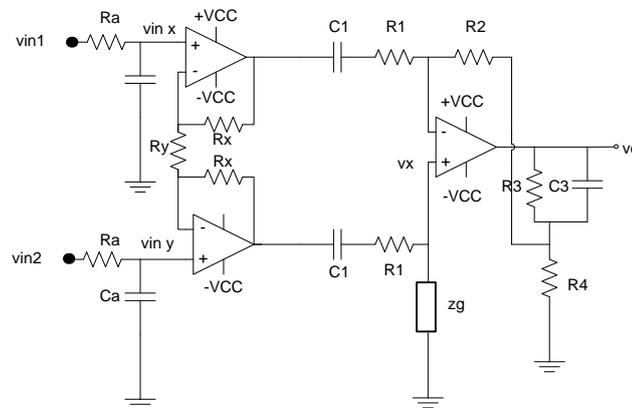


LAMPIRAN B
PENURUNAN FUNGSI TRANSFER PENGUAT
BIOPOTENSIAL

Rangkaian Penguat Biopotensial Sebelum zg Diperoleh



$$vin\ x = \frac{vin1}{(1 + s \cdot ca \cdot Ra)}$$

$$vin\ y = \frac{vin2}{(1 + s \cdot ca \cdot Ra)}$$

Dengan menggunakan prinsip superposisi.

- Saat $vinx$ on dan $viny = 0$, maka:

$$va1 = \left(1 + \frac{Rx}{Ry}\right) \cdot Vin\ x$$

$$vb1 = - \frac{Rx}{Ry} \cdot Vin\ x$$

- Saat $viny$ on dan $vinx = 0$, maka:

$$va1 = - \frac{Rx}{Ry} \cdot Vin\ y$$

$$v_{b1} = \left(1 + \frac{R_x}{R_y}\right) \cdot V_{in\ y}$$

Sehingga:

$$v_a = v_{a1} + v_{a2}$$

$$= \left(1 + \frac{R_x}{R_y}\right) \cdot V_{in\ x} - \frac{R_x}{R_y} \cdot V_{in\ y}$$

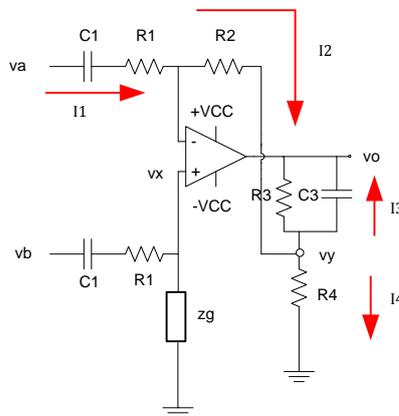
$$v_b = v_{b1} + v_{b2}$$

$$= \left(1 + \frac{R_x}{R_y}\right) \cdot V_{in\ y} - \frac{R_x}{R_y} \cdot V_{in\ x}$$

$$v_b - v_a = \left[\left(1 + \frac{R_x}{R_y}\right) \cdot V_{in\ y} - \frac{R_x}{R_y} \cdot V_{in\ x} \right] - \left[\left(1 + \frac{R_x}{R_y}\right) \cdot V_{in\ x} - \frac{R_x}{R_y} \cdot V_{in\ y} \right]$$

$$v_b - v_a = \left[\left(1 + \frac{2 \cdot R_x}{R_y}\right) \cdot V_{in\ y} - \left(1 + \frac{2 \cdot R_x}{R_y}\right) \cdot V_{in\ x} \right]$$

$$v_b - v_a = \frac{\left(1 + \frac{2 \cdot R_x}{R_y}\right)}{\left(1 + s \cdot c_a \cdot R_a\right)} \cdot (v_{in2} - v_{in1})$$



$$* I_1 = I_2 = I_3 + I_4$$

$$\frac{v_a - v_x}{R1 + 1/sc1} = \frac{v_x - v_y}{R2} = \frac{v_y - v_o}{R3/(1 + sc3R3)} + \frac{v_y}{R4}$$

$$* v_x = \frac{z_g \cdot v_b}{z_g + R1 + 1/sc1}$$

$$* I_1 = I_2$$

$$\frac{v_a - v_x}{R1 + 1/sc1} = \frac{v_x - v_y}{R2}$$

$$\begin{aligned}
va - \frac{zg.vb}{zg + R1 + 1/s.c1} &= \frac{zg.vb}{R2} - vy \\
va.R2 - \frac{zg.R2.vb}{zg + R1 + 1/s.c1} &= \frac{zg.vb.(R1 + s.c1)}{zg + R1 + 1/s.c1} - vy.(R1 + s.c1) \\
vy.(R1 + 1/s.c1) &= \frac{zg.vb.(R1 + s.c1)}{zg + R1 + 1/s.c1} + \frac{zg.R2.vb}{zg + R1 + 1/s.c1} - va.R2 \\
vy &= \frac{zg.vb}{zg + R1 + 1/s.c1} + \frac{zg.vb.(R1 + s.c1)}{(zg + R1 + 1/s.c1).(R1 + 1/s.c1)} - \frac{va.R2}{(R1 + 1/s.c1)} \\
vy &= \frac{s.c1.zg.vb}{1 + s.c1.(zg + R1)} + \frac{s^2.c1^2.zg.R2.vb}{[1 + s.c1.(zg + R1)].(1 + s.c1.R1)} - \frac{va.s.c1.R2}{1 + s.c1.R1}
\end{aligned}$$

Substitusi

$$I_1 = I_3 + I_4$$

$$\frac{va - vx}{R1 + 1/sc1} = \frac{vy - vo}{R3/(1 + sc3R3)} + \frac{vy}{R4}$$

$$\frac{va - vx}{R1 + 1/sc1} = vy \left(\frac{1}{R4} + \frac{1 + s.c3.R3}{R3} \right) + vo \left(\frac{1 + s.c3.R3}{R3} \right)$$

Substitusi vx ke dalam persamaan:

$$\frac{va}{R1 + \frac{1}{sc1}} - \frac{zg.vb}{zg + R1 + \frac{1}{sc1}} = vy \left(\frac{R3 + R4 + s.c3.R3.R4}{(R3.R4)} \right) + vo \left(\frac{1 + s.c3.R3}{R3} \right)$$

$$vo \left(\frac{1 + s.c3.R3}{R3} \right) = vy \left(\frac{R3 + R4 + s.c3.R3.R4}{R3.R4} \right) - \frac{va}{\left(R1 + \frac{1}{sc1} \right)} + \frac{zg.vb}{\left(R1 + \frac{1}{sc1} \right) \cdot \left(zg + R1 + \frac{1}{sc1} \right)}$$

$$vo.(1 + s.c3.R3) = vy \left(\frac{R3 + R4 + s.c3.R3.R4}{R4} \right) - \frac{va.sc1.R3}{(1 + s.c1.R1)} + \frac{s^2.c1^2.zg.R3.vb}{[1 + s.c1.(zg + R1)].(1 + s.c1.R1)}$$

$$vo = vy \left(\frac{R3 + R4 + s.c3.R3.R4}{R4.(1 + s.c3.R3)} \right) - \frac{va.sc1.R3}{(1 + s.c1.R1).(1 + s.c3.R3)} + \frac{s^2.c1^2.zg.R3.vb}{[1 + s.c1.(zg + R1)].(1 + s.c1.R1).(1 + s.c3.R3)}$$

$$\begin{aligned}
vo &= \frac{sc1.zg.(R3 + R4 + s.c3.R3.R4).vb}{R4.(1 + s.c3.R3).[1 + s.c1.(zg + R1)]} \\
&+ \frac{s^2.c1^2.zg.R3.vb.(R3 + R4 + s.c3.R3.R4)}{R4.(1 + s.c3.R3).[1 + s.c1.(zg + R1)].(1 + s.c1.R1)} \\
&- \frac{sc1.R2.(R3 + R4 + s.c3.R3.R4).va}{R4(1 + s.c3.R3).(1 + s.c1.R1)} - \frac{va.sc1.R3}{(1 + s.c1.R1).(1 + s.c3.R3)} \\
&+ \frac{s^2.c1^2.zg.R3.vb}{[1 + s.c1.(zg + R1)].(1 + s.c1.R1).(1 + s.c3.R3)}
\end{aligned}$$

$$vo = \frac{sc1.zg.vb}{(1 + s.c3.R3).[1 + s.c1.(zg + R1)]} \cdot \left[\frac{R3 + R4 + s.c3.R3.R4}{R4} + \frac{sc1.R3}{(1 + s.c1.R1)} \right]$$

$$\begin{aligned}
& - \frac{va}{(1+s.c1.R1).(1+s.c3.R3)} \cdot \left[\frac{(R3+R4+s.c3.R3.R4).s.c1.R2}{R4} + s.c1.R3 \right] \\
vo = & \frac{sc1.zg.vb}{(1+s.c3.R3).[1+s.c1.(zg+R1)]} \cdot \\
& \left[\frac{(1+s.c1.R1).(R3+R4+s.c3.R3.R4)+s.c1.R2.(R3+R4+s.c3.R3.R4)+s.c1.R3.R4}{R4.(1+s.c1.R1)} \right] \\
& - \frac{va}{(1+s.c1.R1).(1+s.c3.R3)} \cdot \left[\frac{(R3+R4+s.c3.R3.R4).s.c1.R2+s.c1.R3.R4}{R4} \right]
\end{aligned}$$

❖ Faktor pengali va

$$\begin{aligned}
& = - \frac{1}{R4} \cdot \left[\frac{s.c1.R2.R4+s.c1.R2.R3+s^2.c1.c3.R2.R3.R4+S.c1.R3.R4}{(1+s.c1.R1).(1+s.c3.R3)} \right] \\
& = - \frac{1}{R4} \cdot \left[\frac{s.[c1.(R2.R4+R2.R3+R3.R4)+s.c1.c3.R2.R3.R4]}{(1+s.c1.R1).(1+s.c3.R3)} \right] \\
& = - \frac{1}{R4} \cdot c1.(R2.R3+R2.R4+R3.R4).s \cdot \left[\frac{1+s.c3.\frac{R2.R3.R4}{(R2.R4+R2.R3+R3.R4)}}{(1+s.c1.R1).(1+s.c3.R3)} \right]
\end{aligned}$$

❖ Faktor pengali vb

$$\begin{aligned}
& = \frac{s.c1.zg}{(1+s.c3.R3).[1+s.c1.(zg+R1)]} \\
& \left[\frac{R3+R4+s.c3.R3.R4+s.c1.R1(R3+R4)+s^2.c1.c3.R1.R3.R4+s.c1.R2.(R3+R4)+s^2.c1.c3.R1.R3.R4+s.c1.R3.R4}{R4.(1+s.c1.R1)} \right] \\
& = \frac{s.c1.zg}{R4} \cdot \left[\frac{R3+R4+s.[c3.R3.R4+c1.((R1+R2)(R3+R4)+R3+R4)]+s^2.c1.c3.R3.R4.(R1+R2)}{(1+s.c1.R1).(1+s.c3.R3).[1+s.c1.(zg+R1)]} \right] \\
& = \frac{c1.zg.(R3+R4).s}{R4} \cdot \left[\frac{1+s.\frac{c3.R3.R4+c1.((R1+R2)(R3+R4)+R3+R4)}{R3+R4}+s^2.\frac{c1.c3.R3.R4.(R1+R2)}{R3+R4}}{(1+s.c1.R1).(1+s.c3.R3).[1+s.c1.(zg+R1)]} \right]
\end{aligned}$$

Maka fungsi transfer rangkaian di atas adalah:

$$\begin{aligned}
vo = & \frac{c1.zg.(R3+R4).s}{R4} \cdot vb \cdot \\
& \left[\frac{1+s.\frac{c3.R3.R4+c1.((R1+R2)(R3+R4)+R3+R4)}{R3+R4}+s^2.\frac{c1.c3.R3.R4.(R1+R2)}{R3+R4}}{(1+s.c1.R1).(1+s.c3.R3).[1+s.c1.(zg+R1)]} \right]
\end{aligned}$$

$$- \frac{1}{R4} \cdot c1 \cdot (R2 \cdot R3 + R2 \cdot R4 + R3 \cdot R4) \cdot s \cdot va \cdot \left[\frac{1 + s \cdot c3 \cdot \frac{R2 \cdot R3 \cdot R4}{(R2 \cdot R4 + R2 \cdot R3 + R3 \cdot R4)}}{(1 + s \cdot c1 \cdot R1) \cdot (1 + s \cdot c3 \cdot R3)} \right]$$

$$K \cdot (vb - va) = X \cdot va - Y \cdot vb$$

Sehingga untuk mencari nilai zg, $X = Y = K$

$$x = \frac{c1 \cdot zg \cdot (R3 + R4) \cdot s}{R4} \cdot \left[\frac{1 + s \cdot \frac{c3 \cdot R3 \cdot R4 + c1 \cdot [(R1 + R2)(R3 + R4) + R3 + R4]}{R3 + R4}}{(1 + s \cdot c1 \cdot R1) \cdot (+s \cdot c3 \cdot R3) \cdot [1 + s \cdot c1 \cdot (zg + R1)]} + s^2 \cdot \frac{c1 \cdot c3 \cdot R3 \cdot R4 \cdot (R1 + R2)}{R3 + R4} \right]$$

$$y = \frac{1}{R4} \cdot c1 \cdot (R2 \cdot R3 + R2 \cdot R4 + R3 \cdot R4) \cdot s \cdot va \cdot \left[\frac{1 + s \cdot c3 \cdot \frac{R2 \cdot R3 \cdot R4}{(R2 \cdot R4 + R2 \cdot R3 + R3 \cdot R4)}}{(1 + s \cdot c1 \cdot R1) \cdot (1 + s \cdot c3 \cdot R3)} \right]$$

- Mencari nilai zg untuk menyederhanakan fungsi transfer.

Misalkan :

$$A = \frac{c1 \cdot (R3 + R4)}{R4}$$

$$B = \frac{c3 \cdot R3 \cdot R4 + c1 \cdot [(R1 + R2)(R3 + R4) + R3 + R4]}{R3 + R4}$$

$$C = \frac{c1 \cdot c3 \cdot R3 \cdot R4 \cdot (R1 + R2)}{R3 + R4}$$

$$D = \frac{1}{R4} \cdot c1 \cdot (R2 \cdot R3 + R2 \cdot R4 + R3 \cdot R4)$$

$$E = c3 \cdot \frac{R2 \cdot R3 \cdot R4}{(R2 \cdot R4 + R2 \cdot R3 + R3 \cdot R4)}$$

* $X=Y$

$$\frac{A \cdot zg \cdot s \cdot (1 + B \cdot s + C \cdot s^2)}{[1 + s \cdot c1 \cdot (zg + R1)]} = D \cdot s \cdot (1 + E \cdot s)$$

$$A \cdot zg \cdot (1 + B \cdot s + C \cdot s^2) = D \cdot (1 + E \cdot s) \cdot [1 + s \cdot c1 \cdot (zg + R1)]$$

$$A \cdot zg \cdot (1 + B \cdot s + C \cdot s^2) = D \cdot (1 + E \cdot s) + D \cdot (1 + E \cdot s) \cdot s \cdot c1 \cdot zg + D \cdot (1 + E \cdot s) \cdot s \cdot c1 \cdot R1$$

$$zg \cdot [A \cdot (1 + B \cdot s + C \cdot s^2) - s \cdot c1 \cdot D \cdot (1 + E \cdot s)] = D \cdot (1 + E \cdot s) + D \cdot (1 + E \cdot s) \cdot s \cdot c1 \cdot R1$$

$$zg = \frac{D \cdot (1 + E \cdot s) + D \cdot (1 + E \cdot s) \cdot s \cdot c1 \cdot R1}{A \cdot (1 + B \cdot s + C \cdot s^2) - s \cdot c1 \cdot D \cdot (1 + E \cdot s)}$$

$$zg = \frac{D \cdot (1 + E \cdot s) \cdot (1 + s \cdot c1 \cdot R1)}{[A \cdot (1 + B \cdot s + C \cdot s^2) - s \cdot c1 \cdot D \cdot (1 + E \cdot s)]}$$

$$zg = \frac{(1 + s \cdot c1 \cdot R1)}{\left[\frac{A \cdot (1 + B \cdot s + C \cdot s^2)}{D \cdot (1 + E \cdot s)} - s \cdot c1 \right]}$$

*Substitusi A,B,C,D,dan E ke dalam persamaan:

$$\begin{aligned}
 z_g &= \left[\frac{c1 \cdot (R3 + R4)}{R4} \cdot \left(1 + \frac{c3 \cdot R3 \cdot R4 + c1 \cdot [(R1 + R2)(R3 + R4) + R3 + R4]}{R3 + R4} \cdot s + \frac{c1 \cdot c3 \cdot R3 \cdot R4 \cdot (R1 + R2)}{R3 + R4} \cdot s^2 \right) - s \cdot c1 \right] \\
 &\quad \left[\frac{1}{R4} \cdot c1 \cdot (R2 \cdot R3 + R2 \cdot R4 + R3 \cdot R4) \cdot \left(1 + c3 \cdot \frac{R2 \cdot R3 \cdot R4}{(R2 \cdot R4 + R2 \cdot R3 + R3 \cdot R4)} \cdot s \right) \right] \\
 &= \frac{(1 + s \cdot c1 \cdot R1) \cdot (R2 \cdot R3 + R2 \cdot R4 + R3 \cdot R4 + s \cdot c3 \cdot R2 \cdot R3 \cdot R4)}{R3 + R4 + s \cdot c3 \cdot R3 \cdot R4 + s \cdot c1 \cdot [(R3 + R4) \cdot R1] + s^2 \cdot c1 \cdot c3 \cdot R1 \cdot R3 \cdot R4} \\
 &= \frac{(1 + s \cdot c1 \cdot R1) \cdot (R2 \cdot R3 + R2 \cdot R4 + R3 \cdot R4 + s \cdot c3 \cdot R2 \cdot R3 \cdot R4)}{R3 + R4 \cdot (1 + s \cdot c1 \cdot R1) + s \cdot c3 \cdot R3 \cdot R4 \cdot (1 + s \cdot c1 \cdot R1)} \\
 &= \frac{(R2 \cdot R3 + R2 \cdot R4 + R3 \cdot R4 + s \cdot c3 \cdot R2 \cdot R3 \cdot R4)}{(R3 + R4 + s \cdot c3 \cdot R3 \cdot R4)} \\
 &= R2 + \frac{R3 \cdot R4}{(R3 + R4 + s \cdot c3 \cdot R3 \cdot R4)} \\
 &= R2 + \frac{\frac{R3 \cdot R4}{R3 + R4}}{(1 + s \cdot c3 \cdot \frac{R3 \cdot R4}{R3 + R4})}
 \end{aligned}$$

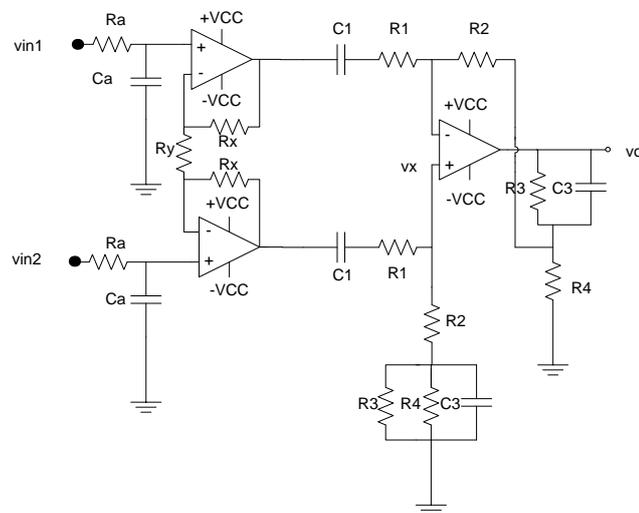
Maka $z_g = R2 + (R3 // R4 // C3)$

// = parallel

+ = seri

- Impedansi z_g diganti dengan impedansi yang diperoleh dari hasil penurunan sehingga rangkaian menjadi:

Rangkaian Penguat Biopotensial Setelah z_g diperoleh



- Fungsi transfer rangkaian keseluruhan adalah sebagai berikut:

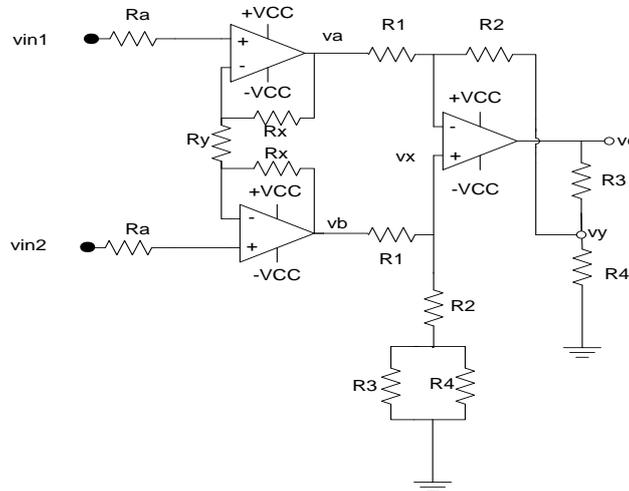
$$v_o = \frac{1}{R_4} \cdot c_1 \cdot (R_2 \cdot R_3 + R_2 \cdot R_4 + R_3 \cdot R_4) \cdot s \cdot \left[\frac{1 + s \cdot c_3 \cdot \frac{R_2 \cdot R_3 \cdot R_4}{(R_2 \cdot R_4 + R_2 \cdot R_3 + R_3 \cdot R_4)}}{(1 + s \cdot c_1 \cdot R_1) \cdot (1 + s \cdot c_3 \cdot R_3)} \right] (v_b - v_a)$$

$$v_o = \frac{1}{R_4} \cdot c_1 \cdot (R_2 \cdot R_3 + R_2 \cdot R_4 + R_3 \cdot R_4) \cdot s \cdot \left[\frac{1 + s \cdot c_3 \cdot \frac{R_2 \cdot R_3 \cdot R_4}{(R_2 \cdot R_4 + R_2 \cdot R_3 + R_3 \cdot R_4)}}{(1 + s \cdot c_1 \cdot R_1) \cdot (1 + s \cdot c_3 \cdot R_3)} \right] \frac{\left(1 + \frac{2 \cdot R_y}{R_x}\right)}{(1 + s \cdot c_a \cdot R_a)} \cdot (v_{in2} - v_{in1})$$

$$\frac{v_o}{(v_{in2} - v_{in1})} = \left[\frac{\left(\frac{1}{R_4} \cdot c_1 \cdot (R_2 \cdot R_3 + R_2 \cdot R_4 + R_3 \cdot R_4) \cdot \left(1 + \frac{2 \cdot R_y}{R_x}\right) \cdot s\right) \left(1 + s \cdot c_3 \cdot \frac{R_2 \cdot R_3 \cdot R_4}{(R_2 \cdot R_4 + R_2 \cdot R_3 + R_3 \cdot R_4)}\right)}{(1 + s \cdot c_1 \cdot R_1) \cdot (1 + s \cdot c_3 \cdot R_3) \cdot (1 + s \cdot c_a \cdot R_a)} \right]$$

$\frac{v_o}{(v_{in2} - v_{in1})} = \frac{\left(1 + \frac{2R_x}{R_y}\right) \cdot C_1 \cdot s \cdot (R_2 \cdot R_3 + R_2 \cdot R_4 + R_3 \cdot R_4 + R_2 \cdot R_3 \cdot R_4 \cdot C_3 \cdot s)}{R_4 \cdot (1 + s \cdot C_1 \cdot R_1) \cdot (1 + s \cdot C_3 \cdot R_3) \cdot (1 + s \cdot C_a \cdot R_a)}$

Fungsi Transfer Penguat Biopotensial Pada Mid Frekuensi



Dengan cara yang sama dengan sebelumnya maka:

$$v_a = \left(1 + \frac{R_x}{R_y}\right) \cdot v_{in1} - \frac{R_x}{R_y} \cdot v_{in2}$$

$$v_b = \left(1 + \frac{R_x}{R_y}\right) \cdot v_{in2} - \frac{R_x}{R_y} \cdot v_{in1}$$

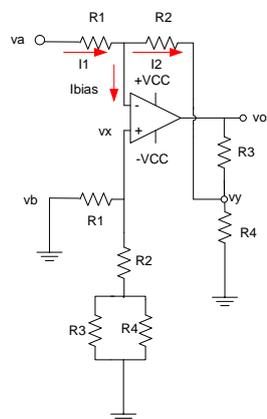
Maka:

$$(v_b - v_a) = \left[\left(1 + \frac{R_x}{R_y}\right) \cdot v_{in2} - \frac{R_x}{R_y} \cdot v_{in1}\right] - \left[\left(1 + \frac{R_x}{R_y}\right) \cdot v_{in1} - \frac{R_x}{R_y} \cdot v_{in2}\right]$$

$$(v_b - v_a) = \left(1 + \frac{2 \cdot R_x}{R_y}\right) (v_{in2} - v_{in1})$$

Dengan prinsip superposisi maka:

- Saat v_a on dan v_b off:



$$v_y = \frac{R_4 \cdot v_{o1}}{R_3 + R_4}$$

Input biased current dianggap $\approx 0A$

$$I_1 = I_2$$

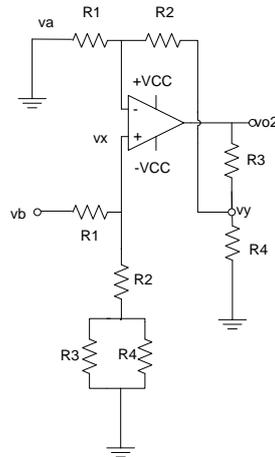
$$\frac{v_a - v_x}{R_1} = \frac{0 - \frac{R_4 \cdot v_{o1}}{R_3 + R_4}}{R_2 + \frac{R_4}{R_3}}, v_x = 0$$

$$v_{o1} = \frac{\frac{v_a}{R_1}}{\frac{R_4}{R_2 \cdot (R_3 + R_4) + R_3 \cdot R_4}}$$

$$v_{o1} = - \frac{v_a \cdot [R_2 \cdot (R_3 + R_4) + R_3 \cdot R_4]}{R_1 \cdot R_4}$$

$$v_{o1} = - \frac{R_2 \cdot R_3 + R_2 \cdot R_4 + R_3 \cdot R_4}{R_1 \cdot R_4} \cdot v_a$$

- Saat v_a off dan v_b on:



$$v_x = \frac{\left(R_2 + \frac{R_3 \cdot R_4}{R_3 + R_4}\right) \cdot v_b}{R_1 + R_2 + \frac{R_3 \cdot R_4}{R_3 + R_4}} \dots \dots \dots (1)$$

$$v_y = \frac{R_4 \cdot v_{o2}}{R_3 + R_4} \dots \dots \dots (2)$$

$$\frac{v_y}{v_x} = 1 + \frac{R_2 + \frac{R_3 \cdot R_4}{R_3 + R_4}}{R_1}$$

$$\frac{v_y}{v_x} = \frac{R_1 + R_2 + \frac{R_3 \cdot R_4}{R_3 + R_4}}{R_1} \dots \dots \dots (3)$$

Substitusi (1) dan (2) ke dalam persamaan (3):

$$\frac{\left(R_2 + \frac{R_3 \cdot R_4}{R_3 + R_4}\right) \cdot v_b}{R_1 + R_2 + \frac{R_3 \cdot R_4}{R_3 + R_4}} = \frac{R_1 + R_2 + \frac{R_3 \cdot R_4}{R_3 + R_4}}{R_1} \cdot \frac{R_4 \cdot v_{o2}}{R_3 + R_4}$$

$$\frac{\left(R_2 + \frac{R_3 \cdot R_4}{R_3 + R_4}\right) \cdot v_b}{\left(\frac{R_4 \cdot v_{o2}}{R_3 + R_4}\right) \cdot R_1 + R_2 + \frac{R_3 \cdot R_4}{R_3 + R_4}} = \frac{R_1 + R_2 + \frac{R_3 \cdot R_4}{R_3 + R_4}}{R_1}$$

$$v_{o2} = \left(\frac{R_3 + R_4}{R_1 \cdot R_4}\right) \cdot \left(R_2 + \frac{R_3 \cdot R_4}{R_3 + R_4}\right) \cdot v_b$$

$$v_{o2} = \frac{v_b \cdot [R_2 \cdot (R_3 + R_4) + R_3 \cdot R_4]}{R_1 \cdot R_4}$$

$$v_{o2} = \frac{[R_2 \cdot R_3 + R_2 \cdot R_4 + R_3 \cdot R_4]}{R_1 \cdot R_4} \cdot v_b$$

Maka :

$$v_o \text{ total} = v_{o1} + v_{o2}$$

$$v_o = - \frac{R_2 \cdot R_3 + R_2 \cdot R_4 + R_3 \cdot R_4}{R_1 \cdot R_4} \cdot v_a + \frac{[R_2 \cdot R_3 + R_2 \cdot R_4 + R_3 \cdot R_4]}{R_1 \cdot R_4} \cdot v_b$$

$$v_o = \frac{R_2 \cdot R_3 + R_2 \cdot R_4 + R_3 \cdot R_4}{R_1 \cdot R_4} \cdot (v_b - v_a)$$

substitusi $(v_b - v_a)$:

$$v_o = \frac{R_2 \cdot R_3 + R_2 \cdot R_4 + R_3 \cdot R_4}{R_1 \cdot R_4} \cdot \left(1 + \frac{2 \cdot R_x}{R_y}\right) \cdot (v_{in2} - v_{in1})$$

Maka fungsi transfer penguat biopotensial pada *mid* frekuensi adalah:

$$TF = \left(1 + \frac{2 \cdot R_x}{R_y}\right) \cdot \frac{R_2 \cdot R_3 + R_2 \cdot R_4 + R_3 \cdot R_4}{R_1 \cdot R_4}$$