

Predmet: ANALOGNA ELEKTRONIKA
Predmetni nastavnik: Dr Nándor Burány

3. semestar
Broj časova: 2+2

POGLAVLJE 2.5.

~~DODATNA KOLA SA~~ ~~OPERACIONIM POJAČAVAČIMA~~



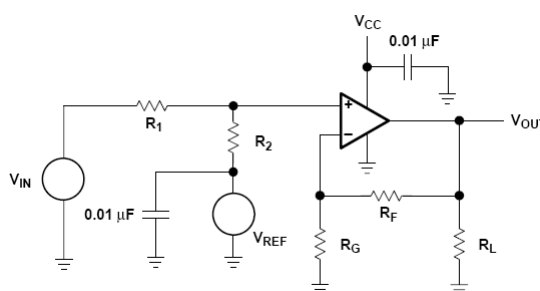
Op Amps For Everyone

Ron Mancini, Editor in Chief

<http://focus.ti.com/lit/an/slod006b/slod006b.pdf>

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Case 1: $V_{OUT} = +mV_{IN} + b$



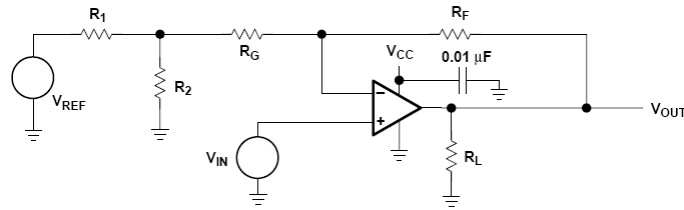
$$V_{OUT} = V_{IN} \left(\frac{R_2}{R_1 + R_2} \right) \left(\frac{R_F + R_G}{R_G} \right) + V_{REF} \left(\frac{R_1}{R_1 + R_2} \right) \left(\frac{R_F + R_G}{R_G} \right)$$

$$m = \left(\frac{R_2}{R_1 + R_2} \right) \left(\frac{R_F + R_G}{R_G} \right)$$

$$b = V_{REF} \left(\frac{R_1}{R_1 + R_2} \right) \left(\frac{R_F + R_G}{R_G} \right)$$

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Case 2: $V_{OUT} = +mV_{IN} - b$



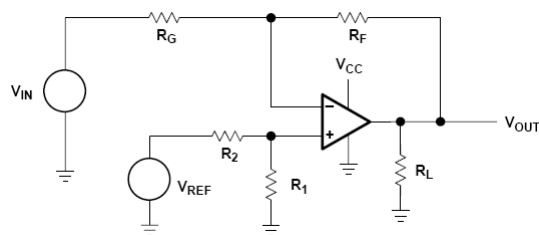
$$V_{OUT} = V_{IN} \left(\frac{R_F + R_G + R_1 \parallel R_2}{R_G + R_1 \parallel R_2} \right) - V_{REF} \left(\frac{R_2}{R_1 + R_2} \right) \left(\frac{R_F}{R_G + R_1 \parallel R_2} \right)$$

$$m = \frac{R_F + R_G + R_1 \parallel R_2}{R_G + R_1 \parallel R_2}$$

$$|b| = V_{REF} \left(\frac{R_2}{R_1 + R_2} \right) \left(\frac{R_F}{R_G + R_1 \parallel R_2} \right)$$

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Case 3: $V_{OUT} = -mV_{IN} + b$



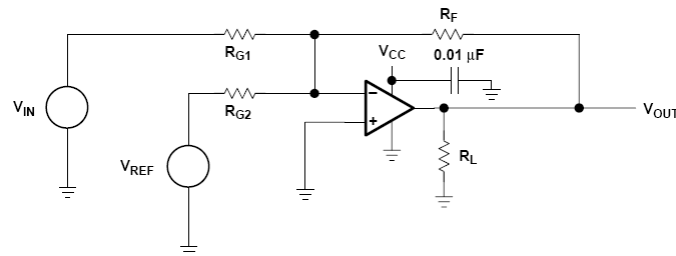
$$V_{OUT} = -V_{IN} \left(\frac{R_F}{R_G} \right) + V_{REF} \left(\frac{R_1}{R_1 + R_2} \right) \left(\frac{R_F + R_G}{R_G} \right)$$

$$|m| = \frac{R_F}{R_G}$$

$$b = V_{REF} \left(\frac{R_1}{R_1 + R_2} \right) \left(\frac{R_F + R_G}{R_G} \right)$$

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Case 4: $V_{OUT} = -mV_{IN} - b$



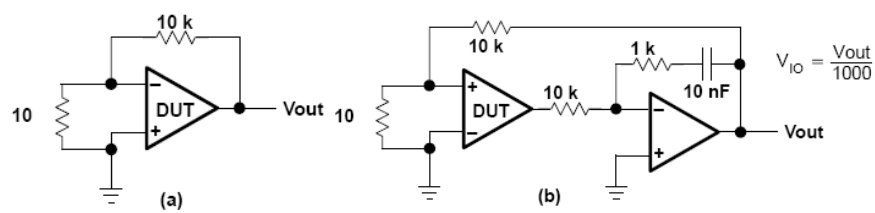
$$V_{OUT} = -V_{IN} \frac{R_F}{R_{G1}} - V_{REF} \frac{R_F}{R_{G2}}$$

$$|m| = \frac{R_F}{R_{G1}}$$

$$|b| = V_{REF} \frac{R_F}{R_{G2}}$$

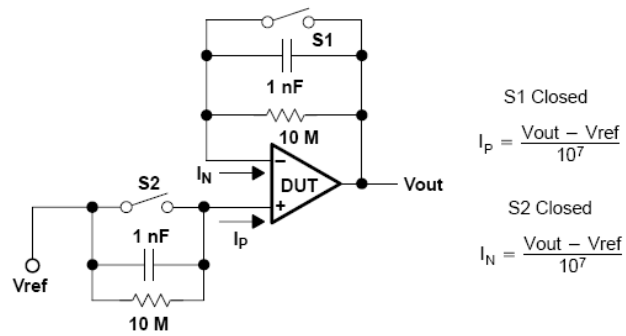
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Test Circuits for Input Offset Voltage



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Test Circuit – I_{IB}



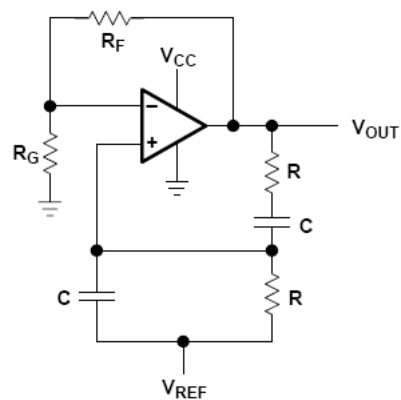
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Wien Bridge Oscillator

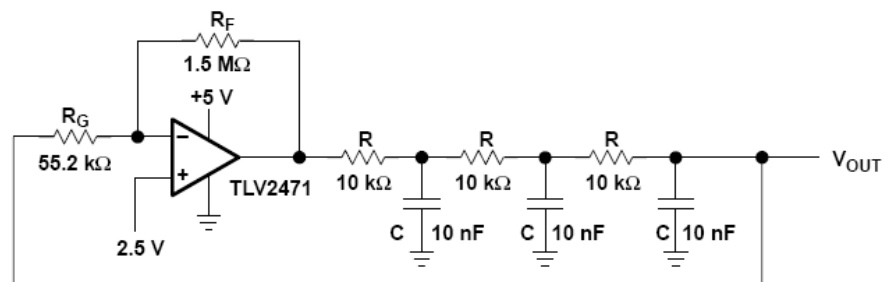
$$V_+ = V_{TEST} \left(\frac{Z_4}{Z_3 + Z_4} \right) = V_{TEST} \left(\frac{\left(\frac{R_2}{R_2 C_2 s + 1} \right)}{\left(\frac{R_2}{R_2 C_2 s + 1} \right) + \left(R_1 + \frac{1}{C_1 s} \right)} \right)$$

$$\frac{V_+}{V_{TEST}} = \frac{1}{1 + R_1 C_2 s + \frac{R_1}{R_2} + \frac{1}{R_2 C_1 s} + \frac{C_2}{C_1}}$$

$$\frac{V_+}{V_{TEST}} = \frac{1}{1 + \frac{R_1}{R_2} + \frac{C_2}{C_1} + j \left(\frac{\omega_0}{\omega_1} - \frac{\omega_2}{\omega_0} \right)}$$

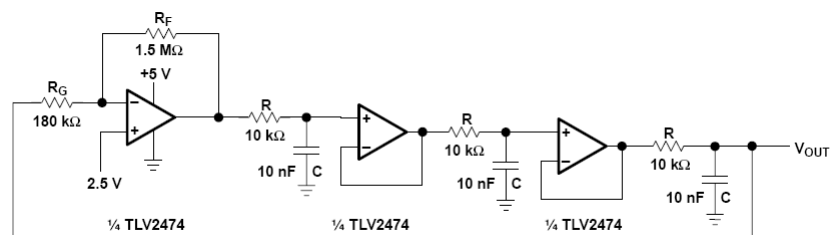


Phase Shift Oscillator, Single Amplifier



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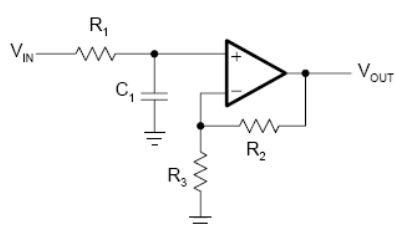
Phase Shift Oscillator, Buffered



$$A\beta = A\left(\frac{1}{RCs + 1}\right)^3$$

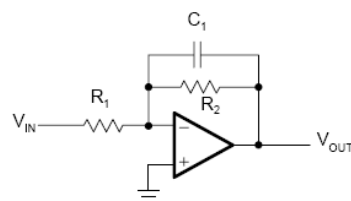
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First-Order Low-Pass Filter



First-Order Noninverting Low-Pass Filter

$$A(s) = \frac{1 + \frac{R_2}{R_3}}{1 + \omega_c R_1 C_1 s}$$

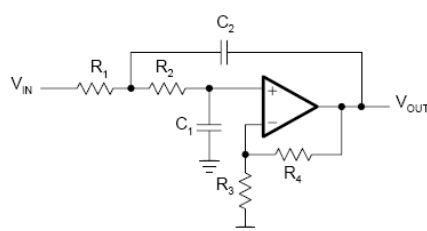


First-Order Inverting Low-Pass Filter

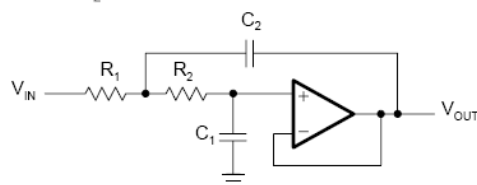
$$A(s) = \frac{-\frac{R_2}{R_1}}{1 + \omega_c R_2 C_1 s}$$

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Second-Order Low-Pass Filter



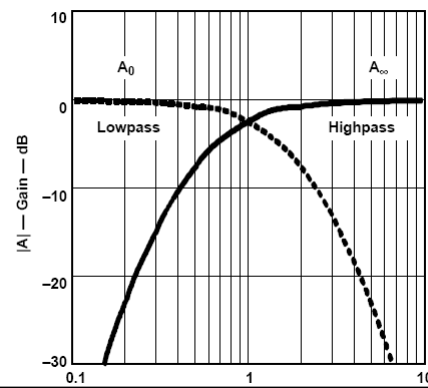
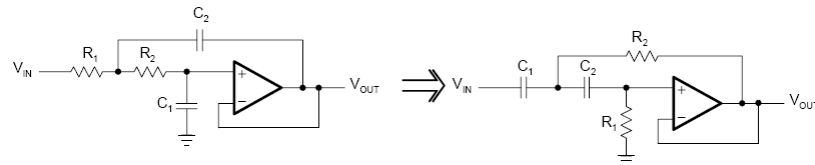
$$A(s) = \frac{A_0}{1 + \omega_c [C_1(R_1 + R_2) + (1 - A_0) R_1 C_2] s + \omega_c^2 R_1 R_2 C_1 C_2 s^2}$$



$$A(s) = \frac{1}{1 + \omega_c C_1 (R_1 + R_2) s + \omega_c^2 R_1 R_2 C_1 C_2 s^2}$$

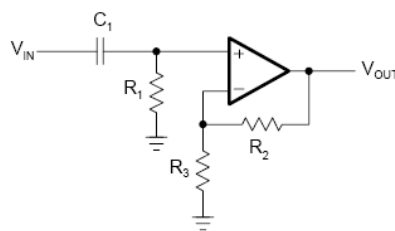
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High-Pass Filter Design

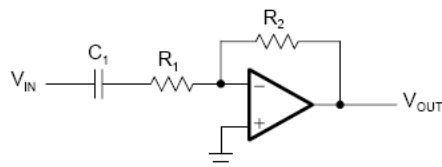


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First-Order High-Pass Filter



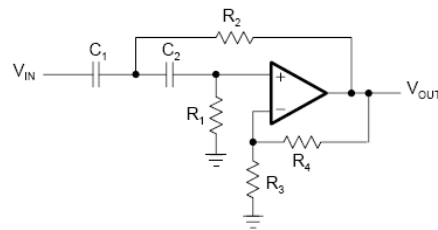
First-Order Noninverting High-Pass Filter



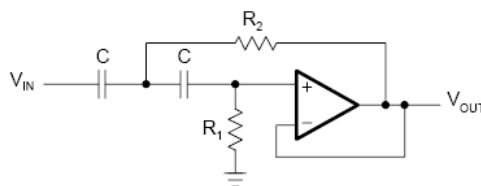
First-Order Inverting High-Pass Filter

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Second-Order High-Pass Filter



$$A(s) = \frac{\alpha}{1 + \frac{R_2(C_1+C_2)+R_1C_2(1-\alpha)}{\omega_c R_1 R_2 C_1 C_2} \cdot \frac{1}{s} + \frac{1}{\omega_c^2 R_1 R_2 C_1 C_2} \cdot \frac{1}{s^2}} \quad \text{with} \quad \alpha = 1 + \frac{R_4}{R_3}$$

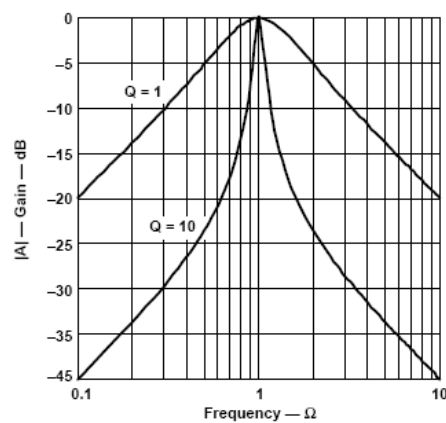


$$A(s) = \frac{1}{1 + \frac{2}{\omega_c R_1 C} \cdot \frac{1}{s} + \frac{1}{\omega_c^2 R_1 R_2 C^2} \cdot \frac{1}{s^2}}$$

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Second-Order Band-Pass Filter

$$A(s) = \frac{\frac{A_m}{Q} \cdot s}{1 + \frac{1}{Q} \cdot s + s^2}$$



Gain Response of a Second-Order Band-Pass Filter

Sallen-Key Band-Pass

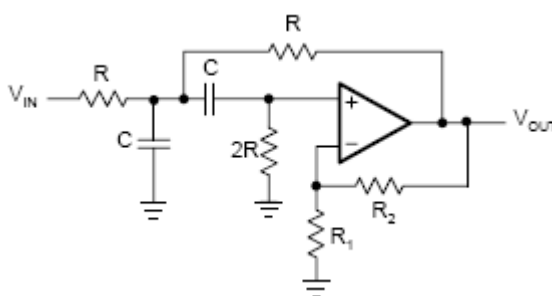
$$A(s) = \frac{G \cdot RC\omega_m \cdot s}{1 + RC\omega_m(3 - G) \cdot s + R^2C^2\omega_m^2 \cdot s^2}$$

mid-frequency: $f_m = \frac{1}{2\pi RC}$

inner gain: $G = 1 + \frac{R_2}{R_1}$

gain at f_m : $A_m = \frac{G}{3 - G}$

filter quality: $Q = \frac{1}{3 - G}$



Kraj poglavlja 2.5.

(DODATNA KOLA SA OPERACIONIM
POJAČAVAČIMA)