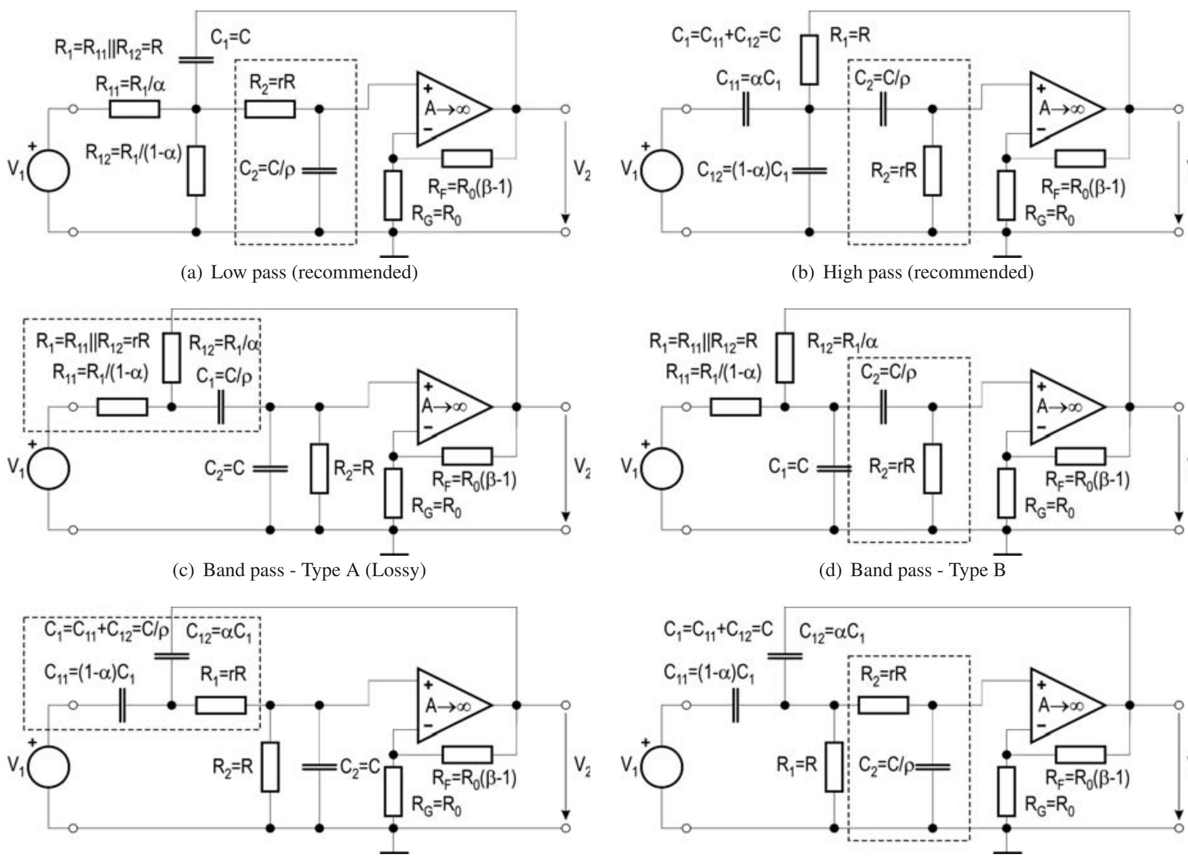
Table 1. Transfer function coefficients of second-order active-RC filters with positive feedback in Fig. 2.

Coefficient	**(a)** Low pass	**(b)** High pass	**(c)** Band pass -Type A
$a_0 = \omega_p^2$	$(R_1R_2C_1C_2)^{-1}$	$(R_1R_2C_1C_2)^{-1}$	$(R_1R_2C_1C_2)^{-1}$
$a_1 = \frac{\omega_p}{q_p}$	$\frac{R_1(C_1+C_2)+R_2C_2-\beta R_1C_1}{R_1R_2C_1C_2}$	$\frac{(R_1+R_2)C_2+R_1C_1-\beta R_2C_2}{R_1R_2C_1C_2}$	$\frac{R_2(C_1+C_2)+R_1C_1-\alpha\beta\cdot R_2C_1}{R_1R_2C_1C_2}$
K	$\alpha\beta$	$\alpha\beta$	$(1-\alpha)\beta\, q_p\sqrt{(R_2C_1)/(R_1C_2)}$
Coefficient	**(d)** Band pass -Type B	**(e)** Band pass -Type A Dual	**(f)** Band pass -Type B Dual
$a_0 = \omega_p^2$	$(R_1R_2C_1C_2)^{-1}$	$(R_1R_2C_1C_2)^{-1}$	$(R_1R_2C_1C_2)^{-1}$
$a_1 = \frac{\omega_p}{q_p}$	$\frac{(R_1+R_2)C_2+R_1C_1-\alpha\beta\cdot R_2C_2}{R_1R_2C_1C_2}$	$\frac{R_2(C_1+C_2)+R_1C_1-\alpha\beta\cdot R_2C_1}{R_1R_2C_1C_2}$	$\frac{(R_1+R_2)C_2+R_1C_1-\alpha\beta\cdot R_1C_1}{R_1R_2C_1C_2}$
K	$(1-\alpha)\beta\, q_p\sqrt{(R_2C_2)/(R_1C_1)}$	$(1-\alpha)\beta\, q_p\sqrt{(R_2C_1)/(R_1C_2)}$	$(1-\alpha)\beta\, q_p\sqrt{(R_1C_1)/(R_2C_2)}$



(a) Low pass (recommended)

(b) High pass (recommended)

(c) Band pass - Type A (Lossy)

(d) Band pass - Type B

(e) Band pass -Type A (Lossy) Dual

(f) Band pass - Type B Dual

Fig. 2. Second-order active-RC filters with positive feedback and impedance scaling factors r and ρ

It can readily be seen that sensitivities in (10) are inversely proportional to the square root of r and partially proportional to the square root of ρ. (By *partial proportionality* we mean that ρ will appear partially in the numerator, partially in the denominator.)

Consequently, to reduce the sensitivity expressions, proportional quantities have to be decreased, those inversely proportional increased, and those partially proportional should be equal to unity.

Thus, the sensitivities in (10) can be reduced by increasing the resistive scaling factor r while keeping the capacitive scaling factor ρ equal to unity. This will be the optimum strategy for desensitization of the HP filter to passive component tolerances (it is referred to as *partial tapering of the resistors* or *resistive tapering*). The high-impedance *RC* section is marked by the rectangle in Fig-

Table 3. Transfer function coefficients of second-order active-RC filters with negative feedback in Fig. 3.

Coefficient	**(a)** Low pass	**(b)** High pass	**(c)** Band pass -Type Lossy
$a_0=\omega_p^2$	$[1-(1-\alpha)\bar{\beta}]/(R_1R_2C_1C_2)$	$\left\{R_1R_2C_1C_2\left[1-(1-\alpha)\bar{\beta}\right]\right\}^{-1}$	$(R_1R_2C_1C_2)^{-1}$
$a_1=\frac{\omega_p}{q_p}$	$\frac{(R_1+R_2)C_2+R_1C_1-\bar{\beta}R_1C_1}{R_1R_2C_1C_2}$	$\frac{R_2(C_1+C_2)+R_2C_2-\bar{\beta}R_2C_2}{R_1R_2C_1C_2}$	$\frac{R_2(C_1+C_2)+R_1C_1-\bar{\beta}\cdot R_2C_1}{R_1R_2C_1C_2}$
K	$(1-\alpha)\bar{\beta}/[1-(1-\alpha)\bar{\beta}]$	$(1-\alpha)\bar{\beta}/[1-(1-\alpha)\bar{\beta}]$	$\alpha\bar{\beta}\,q_p\sqrt{(R_2C_1)/(R_1C_2)}$
Coefficient	**(d)** Band pass -Type R	**(e)** Band pass -Type C	**(f)** Band pass -Type Lossy Dual
$a_0=\omega_p^2$	$(R_1R_2C_1C_2)^{-1}$	$(R_1R_2C_1C_2)^{-1}$	$(R_1R_2C_1C_2)^{-1}$
$a_1=\frac{\omega_p}{q_p}$	$\frac{(R_1+R_2)C_2+R_1C_1-\bar{\beta}R_2C_2}{R_1R_2C_1C_2}$	$\frac{R_1(C_1+C_2)+R_2C_2-\bar{\beta}R_1C_1}{R_1R_2C_1C_2}$	$\frac{R_2(C_1+C_2)+R_1C_1-\bar{\beta}\cdot R_2C_1}{R_1R_2C_1C_2}$
K	$\alpha\bar{\beta}\,q_p\sqrt{(R_2C_2)/(R_1C_1)}$	$\alpha\bar{\beta}\,q_p\sqrt{(R_1C_1)/(R_2C_2)}$	$\alpha\bar{\beta}\,q_p\sqrt{(R_2C_1)/(R_1C_2)}$

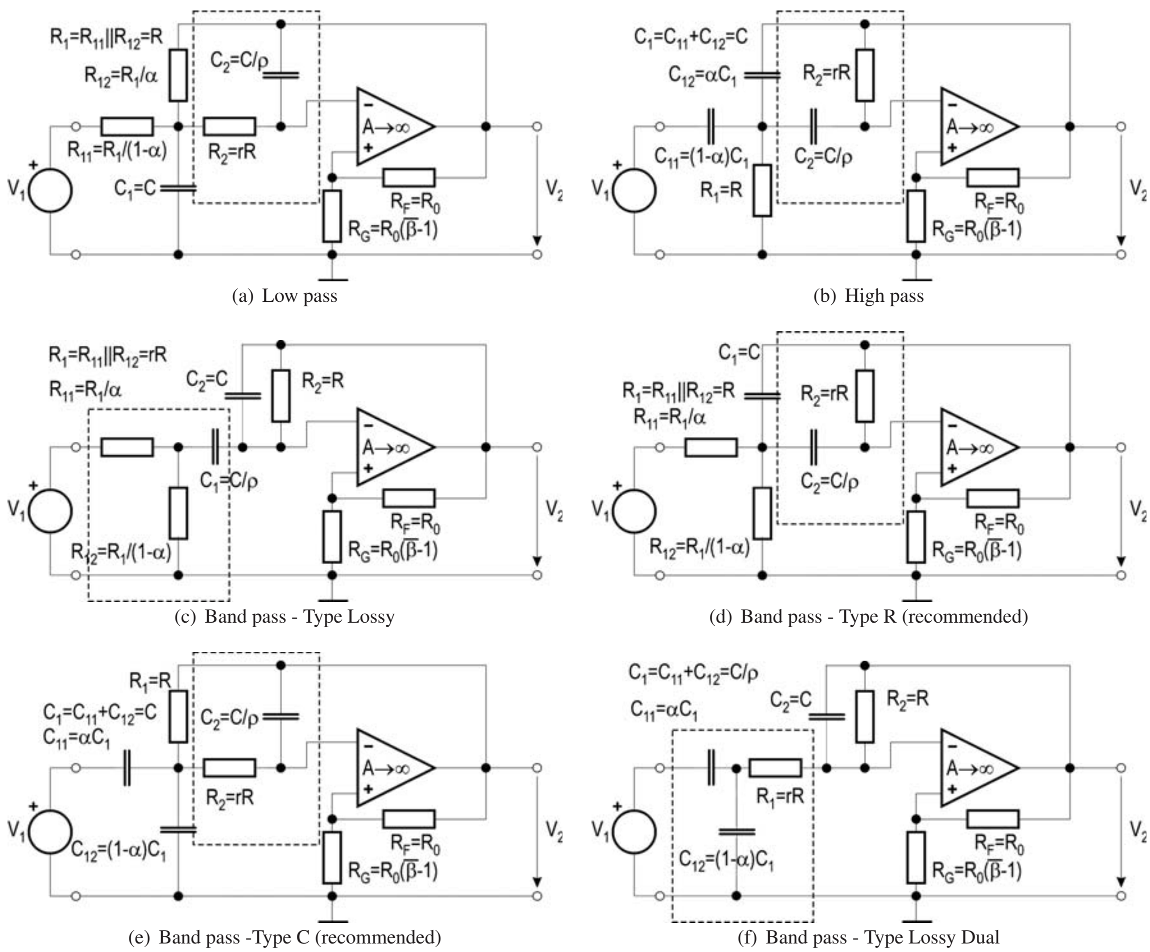


Fig. 3. Second-order active-RC filters with negative feedback and impedance scaling factors r and ρ

The corresponding normalized pole parameters are ω_{p1}=1.00802, q_{p1}=8.8418 (max. Q), ω_{p2}=0.82273, $q_{p2}=2.575546$ (mid. Q), and ω_{p3}=0.503863, $q_{p3}=1.091552$ (min. Q). The resulting transfer function is:

$$T(s)=\frac{k}{(s+0.25617)(s^2+0.114006s+1.01611)}\times\frac{0.0447309}{(s^2+0.3194s+0.676884)(s^2+0.4616s+0.25388)}. \tag{14}$$

In the even-order Chebyshev LP filter, the d.c. gain k

6.5 Generalized Sallen-Key Filter Topology (GSK)

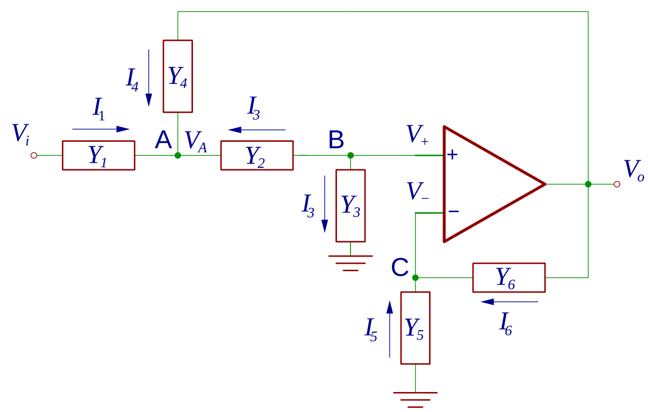


Figure 6.6: Generalized Sallen-Key Topology.

Let's consider the circuit in Figure 6.6 with generic admittances Y_1, Y_2, Y_3, Y_4, Y_5, and Y_6. Applying the KCL to node A , we have

$$(V_i - V_A)\,Y_1 + (V_o - V_A)\,Y_4 + (V_+ - V_A)\,Y_2 = 0\,. \tag{6.2}$$

Applying KCL to node B

$$(V_+ - V_A)\,Y_2 + V_+ Y_3 = 0 \quad \Rightarrow \quad V_A = \frac{Y_2 + Y_3}{Y_2} V_+\,.$$

Applying KCL to node C

$$(V_0 - V_-)\,Y_6 - V_- Y_5 = 0 \quad \Rightarrow \quad V_- = V_+ = \frac{Y_6}{Y_6 + Y_5} V_0\,.$$

Replacing the expression found for V_A, and V_+ into eq. (6.2) and after quite some boring algebra, we obtain

$$\frac{V_o}{V_i} = \left(1 + \frac{Y_5}{Y_6}\right) \frac{Y_1 Y_2 Y_6}{Y_1 Y_6\,(Y_2 + Y_3) + Y_3 Y_6\,(Y_2 + Y_4) - Y_2 Y_4 Y_5}\,.$$

Let's analyze some admittances' configuration of the this filter topology.