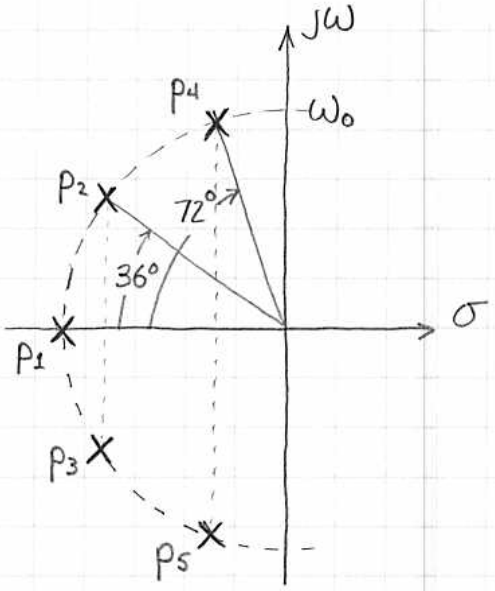
# Example: DESIGN OF A 5th ORDER BUTTERWORTH LOWPASS FILTER USING SALLEN AND KEY CIRCUITS

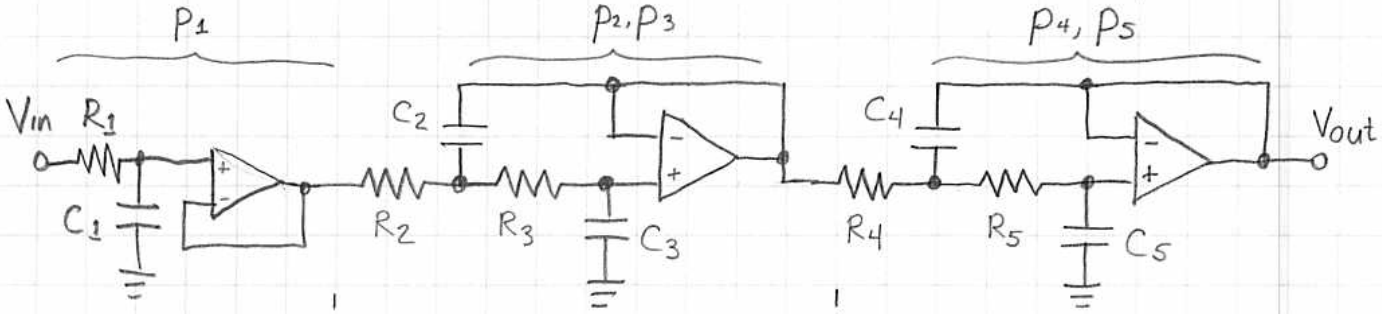
Nth order Butterworth has N poles in the left half plane, on a semicircle of radius $\omega_o$, equally spaced 180°/N apart. For N=5:

Pole $p_1$ can be realized with a simple RC circuit. Pole pairs $p_2/p_3$ and $p_4/p_5$ can each be realized with Sallen and Key circuits

Filter topology, for $f_{3dB} = 1\,kHz$

$\omega_o = 2\pi(1\,kHz)$




$$\frac{1}{2\pi R_1 C_1} = 1\,kHz$$

$R_1 = 16\,k\Omega$

$C_1 = 0.01\,\mu F$

$\omega_o = 995\,Hz$

$$\tan(36°) = \sqrt{\frac{C_2}{C_3} - 1} = 0.7265$$

$$\frac{C_2}{C_3} = 1.528$$

$C_2 = 0.015\,\mu F$, $C_3 = 0.01\,\mu F$ } $\theta = 35.3°$

$$2\pi(1\,kHz) = \frac{1}{R\sqrt{(0.015\,\mu F)(0.01\,\mu F)}}$$

$R = 12.99\,k\Omega \approx 13\,k\Omega$

$R_2 = R_3 = 13.0\,k\Omega$

$\omega_o = 999\,Hz$

$$\tan(72°) = \sqrt{\frac{C_4}{C_5} - 1} = 3.078$$

$$\frac{C_4}{C_5} = 10.47$$

$C_4 = 0.1\,\mu F$, $C_5 = 0.01\,\mu F$ } $\theta = 71.6°$

$$2\pi(1\,kHz) = \frac{1}{R\sqrt{(0.01\,\mu F)(0.1\,\mu F)}}$$

$R = 5.033\,k\Omega \approx 5.1\,k\Omega$

$R_4 = R_5 = 5.1\,k\Omega$

$\omega_o = 987\,Hz$