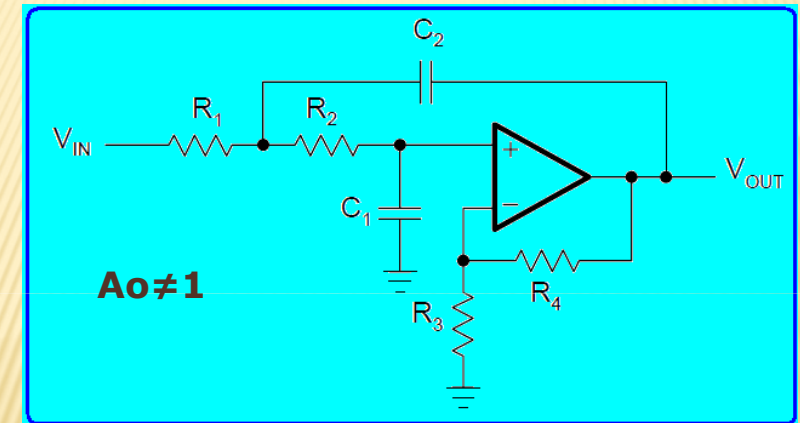


**"SÍNTESIS DE  
FILTROS MODERNOS"  
"PARTE 3 - FILTROS ACTIVOS"  
"NORMALIZACIÓN"**

**Ing. Juan José GARCÍA ABAD**

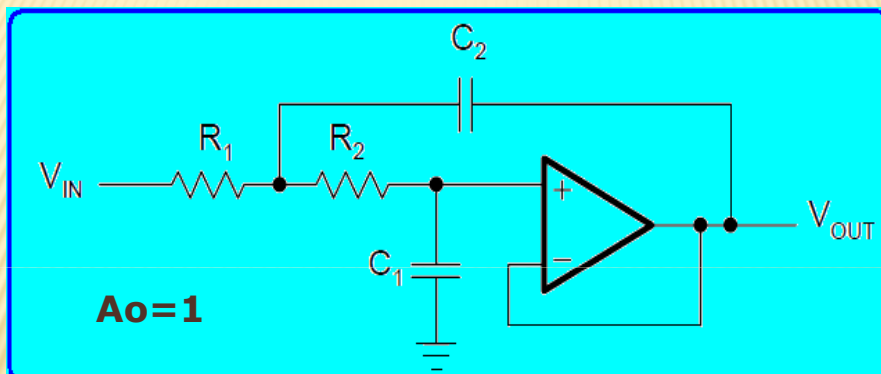
TEORÍA DE LOS  
CIRCUITOS II

### TOPOLOGIA SALLEN-KEY PASA-BAJOS



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

### TOPOLOGIA SALLEN-KEY PASA-BAJOS



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

### TOPOLOGIA SALLEN-KEY PASA-BAJOS

**K ≠ 1**

$$F(P) = \frac{k/R_1 R_2 C_1 C_2}{s^2 + s \left( \frac{1}{R_1 C_1} + \frac{1}{R_2 C_1} + \frac{1-k}{R_2 C_2} \right) + \frac{1}{R_1 R_2 C_1 C_2}}$$

$$F(P) = \frac{K}{s^2 + \frac{\omega_p}{Q_p} s + \omega_p^2}$$

$$k = 1 + \frac{Rb}{Ra}$$

$$F(P) = \frac{K}{s^2 + \frac{\omega_p}{Q_p}s + \omega_p^2}$$

$$\omega_p = \sqrt{\frac{1}{R_1 R_2 C_1 C_2}}$$

$$Q_p = \frac{\omega_p}{(bw)_p} = \frac{\sqrt{\frac{1}{R_1 R_2 C_1 C_2}}}{\frac{1}{R_1 C_1} + \frac{1}{R_2 C_1} + \frac{1-k}{R_2 C_2}}$$

$$K = \frac{k}{R_1 R_2 C_1 C_2}$$

**DISEÑOS DE CIRCUITOS BASADOS EN CELDAS DE SALLEN-KEY DE SEGUNDO GRADO, PASA BAJOS Y PASA ALTOS CON EL SIGUIENTE CONCEPTO DE DISEÑO:**

$$K = 1 \quad R1 = R2 = 1 \, \Omega$$

$$C_1 = \frac{2 Q_P}{\omega_P} \quad C_2 = \frac{1}{2 Q_P \omega_P}$$

$$C_1 = \frac{2 Q_P}{\omega_P} = \frac{2 \cdot 0.707}{1} = 1.4142 [F]$$

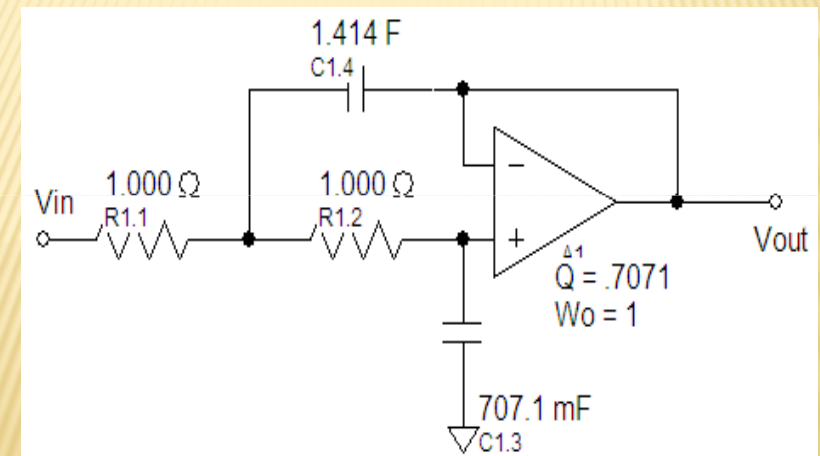
2nd Order Low Pass Butterworth

$$\frac{1}{S^2 + 1.414S + 1}$$

$$\begin{aligned} \omega_0 &= 1 \\ Q &= .7071 \end{aligned}$$

$$C_2 = \frac{1}{2 Q_P \omega_P} = \frac{1}{2 \cdot 0.707 \cdot 1} = 0.707 [F]$$

**Filtro pasa-bajos Sallen-Key normalizado de Butterworth (Amax = 3 [dB])**



**CIRCUITOS BASADOS EN CELDAS DE  
SALLEN-KEY DE SEGUNDO GRADO,  
PASA BAJOS Y PASA ALTOS DE  
BUTTERWORTH, BESSEL Y CHEBYSHEV ,  
NORMALIZADOS  
CON  $\omega_c = 1$  [rps] y  $R = 1$  [ $\Omega$ ]**

$$R_x = R_n * R_{TABLA}$$

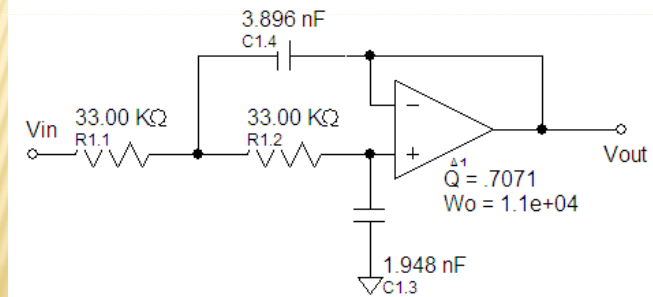
$$C_x = \frac{C_n}{\omega_p * R_x} = \frac{C_n}{2 * \pi * f_p * R_x}$$

**EJEMPLO: CALCULAR FILTRO pb de  
BUTTERWORTH  
CON  $\omega_c = 11000$  [rps] y  $R = 33$  [K $\Omega$ ]**

**FILTRO PASA-BAJOS DE BUTTERWORTH DE ORDEN 2  
 $\omega_c = 11000$  [rps] y  $R = 33$  K**

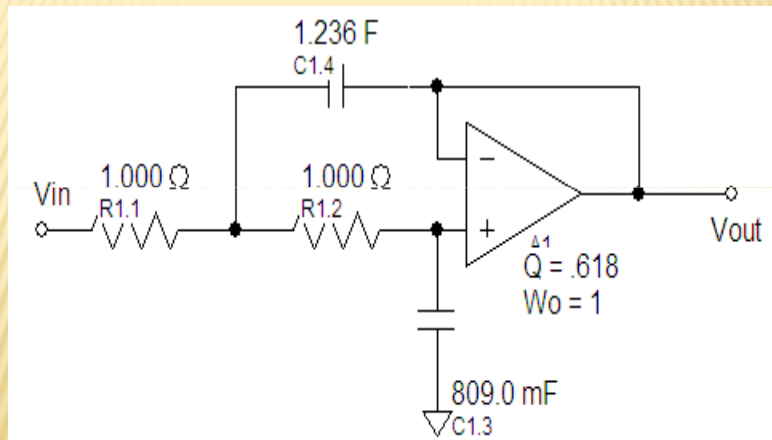
**2nd Order Low Pass Butterworth**

Pass Band Frequency = 11.00 KRad/Sec



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**Filtro pasa-bajos Sallen-Key normalizado de  
BESSEL (Amax = 3 [dB])**

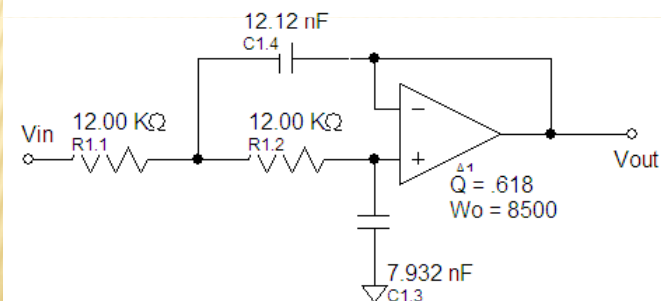


**EJEMPLO:  $\omega_c = 8500$  [rps] y  $R = 12$  [K $\Omega$ ]**

**FILTRO PASA-BAJOS DE BESSEL DE ORDEN 2  
 $\omega_c = 8500$  [rps] y  $R = 12$  K**

**2nd Order Low Pass Linear Phase**

Pass Band Frequency = 8.500 KRad/Sec    Ripple Period = 2  
Group Delay Roll Off = 5.253 KRad/Sec

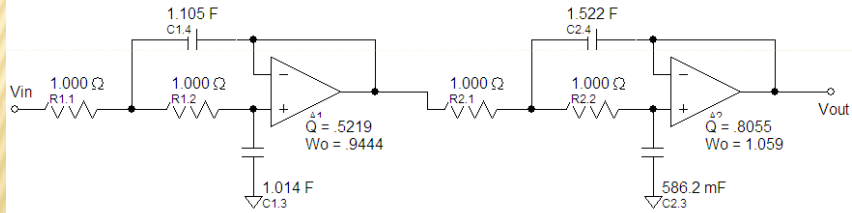


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## FILTRO DE BESSEL NORMALIZADO DE ORDEN 4

### 4th Order Low Pass Bessel

Pass Band Frequency = 1.000 Rad/Sec



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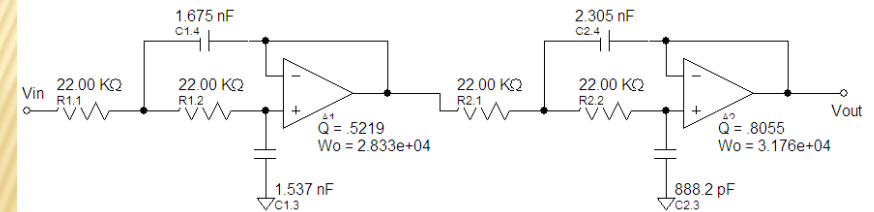
**EJEMPLO:  $\omega_c = 30000$  [rps] y  $R = 22$  [K $\Omega$ ]**

## FILTRO PASA-BAJOS DE BESSEL DE ORDEN 4

**$W_c = 30000$  [rps] y  $R_X = 22$  K**

### 4th Order Low Pass Bessel

Pass Band Frequency = 30.00 KRad/Sec



Tue Nov 13 22:06:07 2018