SALLEN-KEY TOPOLOGY WITH BUTTERWORTH CHARACTERISTIC (R_F/R_I)

[66. Low Pass Active Filters - YouTube]

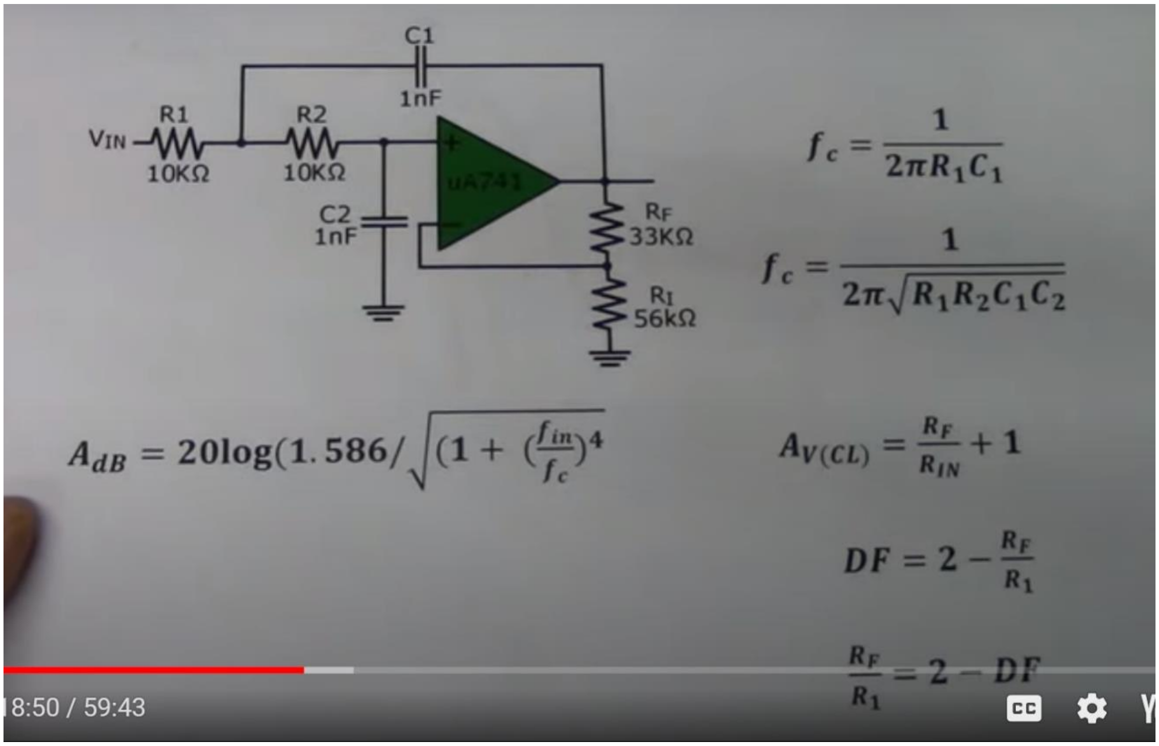


Figure 1: 2-Pole Active Filter. R1 & C2 are one pole and C1 and R2 Comprise the Second pole.

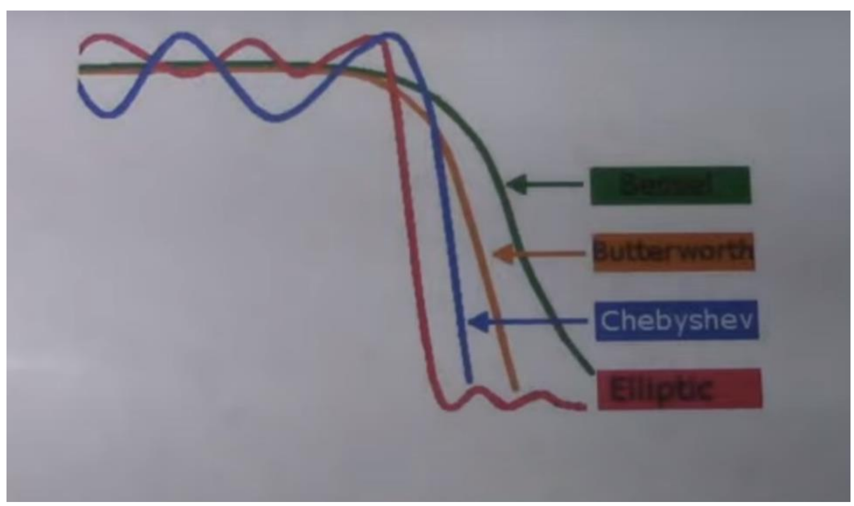


Figure 2: Comparison of Filter Families. Damping Factor Determines the Curve Characteristics

- Butterworth:
  - Flat response
  - Maximally flat
  - Phase shift
  - NOT for audio because it produces phase shifting in the output!
- Bessel:
  - Good for pulse signals
  - No phase shift
  - Low roll off
- Chebyshev
  - Rapid roll-off
  - Gain is NOT constant
- Elliptic (Low-pass and notch filter combined)
  - Gain is not constant
  - Good roll-off

The Damping factor determines the type of filter. It is set by R_F and R_I. DF = 2- R_f/R_i. (Figure 1).

- Gain of 4dB = Butterworth.
- Gain > 4dB = Chebyshev
- Gain < 4dB = Bessel
- A change in the gain affects the characteristics and damping.

The Butterfield etc. filters REQUIRE a mulit-pole design. Single pole filters do not have a damping factor.

A pole represents a resistor and capacitor. In Figure 3, that would be R1 and C1.

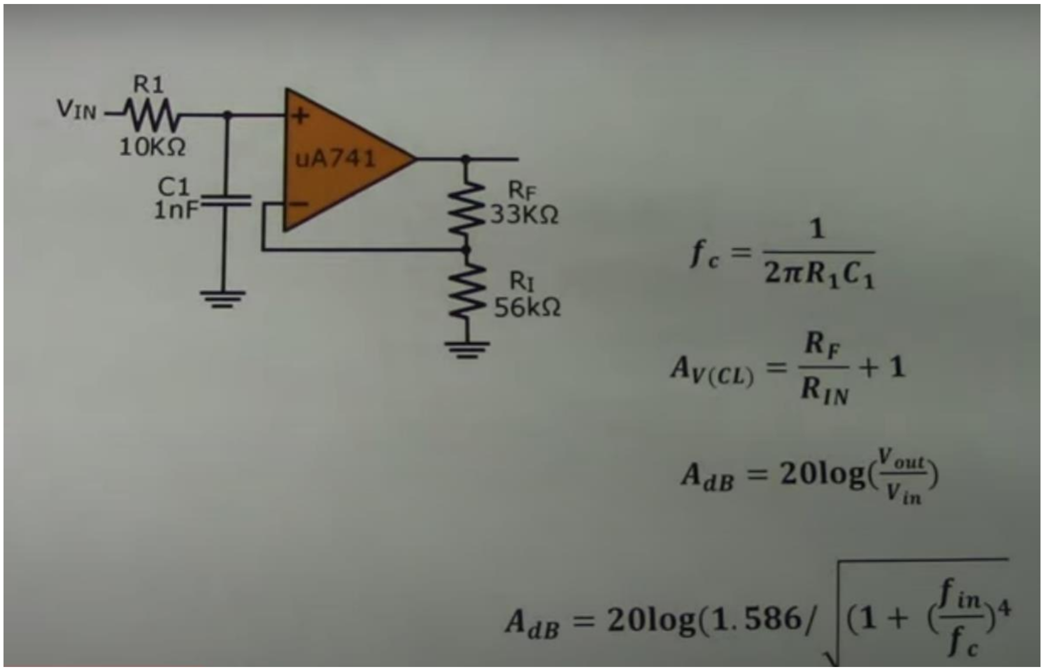
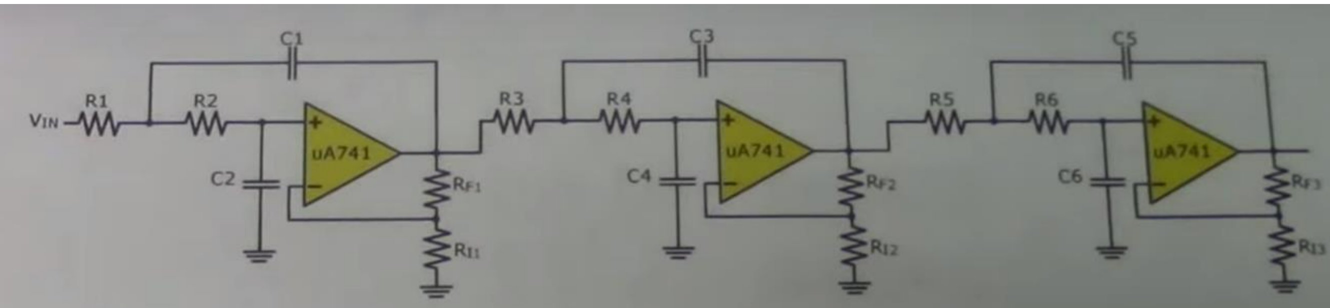


Figure 3: Single Pole Active Low-Pass Filter.

Six-Pole Filter. Each pole provides 20dB roll-off/decade. This filter has 120dB/decade. Resistors in feedback network must be changed in order to maintain 4dB (Butterworth). Gain also increase by 4dB per stage.

Damping factor changes with the number of stages.



Resistor Ratios							
Poles	Stage 1 R_F/R_I	Stage 2 R_{F2}/R_{I2}	Stage 3 R_{F3}/R_{I3}	Stage 4 R_{F4}/R_{I4}	A_V	dB Gain	Roll-Off dB/Decade
2	0.586				1.586	4dB	40
4	0.152	1.235			2.57	8dB	80
6	0.068	0.586	1.483		4.21	12dB	120
8	0.038	0.337	0.889	1.610	6.84	17dB	160

Figure 4: Damping Factor & Resistor Values for Butterworth Family

UNITY GAIN SALLEN-KEY DESIGN

1V in = 1V out.

Use Capacitors to determine damping factor. Ratio of C2/C1 must be .5 for butterworth characteristics.

To create a high-pass, just reverse location of resistors and capacitors.