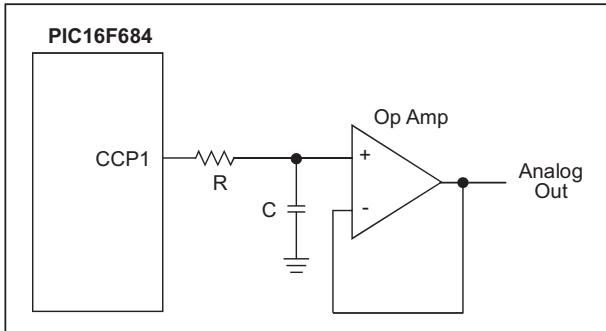


## TIP #16 Generating an Analog Output

Figure 16-1: Low-Pass Filter



Pulse-width modulated signals can be used to create Digital-to-Analog (D/A) converters with only a few external components. Conversion of PWM waveforms to analog signals involves the use of an analog low-pass filter. In order to eliminate unwanted harmonics caused by a PWM signal to the greatest degree possible, the frequency of the PWM signal ( $F_{PWM}$ ) should be significantly higher than the bandwidth ( $F_{BW}$ ) of the desired analog signal. Equation 16-1 shows this relation.

### Equation 16-1

$$F_{PWM} = K * F_{BW}$$

Where harmonics decrease as K increases

R and C are chosen based on the following equation:

### Equation 16-2

$$RC = 1/(2\pi F_{BW})$$

Pick a value of C arbitrarily and then calculate R. The attenuation of the PWM frequency for a given RC filter is:

### Equation 16-3

$$Att(dB) = -10 * \log[1 + (2\pi F_{PWM} RC)^2]$$

If the attenuation calculated in Equation 16-3 is not sufficient, then K must be increased in Equation 16-1. See Application Note AN538 “Using PWM to Generate Analog Output in PIC17C42” for more details on using PWM to generate an analog output.