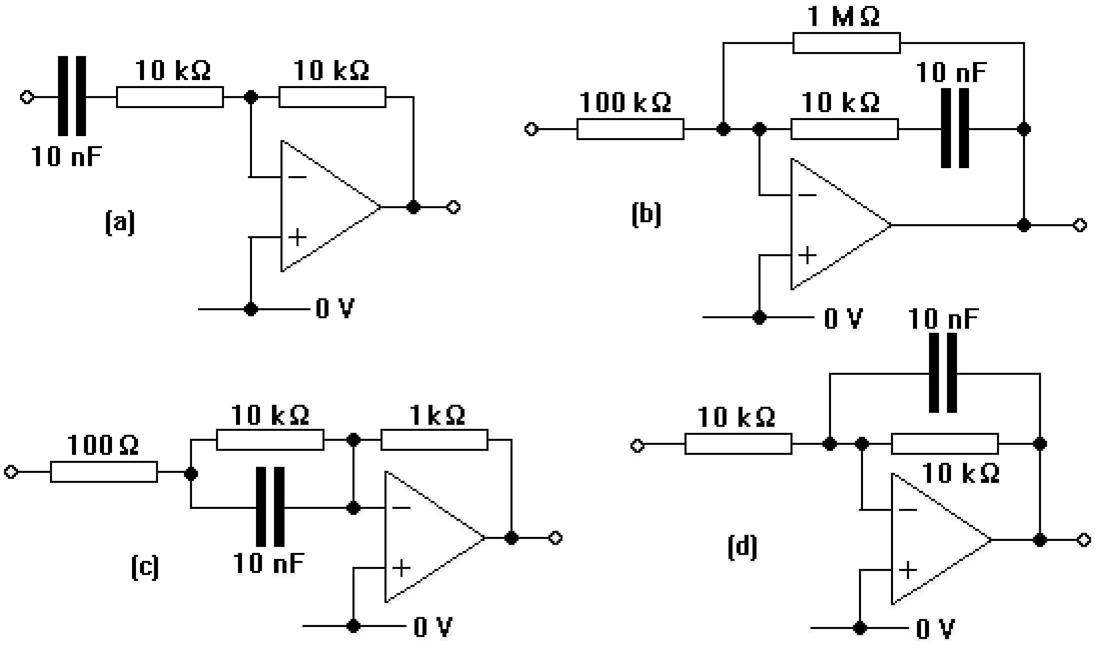
Investigating active filters

You are going to measure the gain-frequency curves for the four active filter circuits shown below.



1. Calculate the break frequency of the first circuit.

2. Use the two-straight line approximation to draw the gain-frequency on log-log graph paper.

3. Assemble the circuit. Set up a double-beam CRO so that it can monitor the signals at the input and output of the filter. Trigger on the input signal.

4. Use a signal generator to inject a 1.0 V peak signal at 33 kHz into the filter. Measure the peak voltage at the output. Calculate the gain of the filter. It should be 1.0.

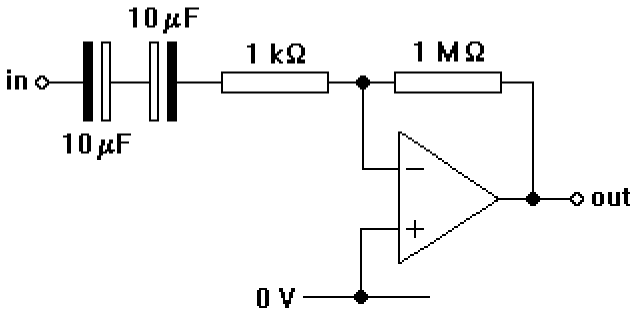
5. Repeat step 4 for the following frequencies: 10 kHz, 3.3 kHz, 1.0 kHz, 330 Hz and 100 Hz.

6. Plot the six measured points on your log-log graph paper.

7. Repeat steps 1 to 6 for the three other filters in the diagram above.

The unity-gain frequency of an op-amp

1. Assemble the circuit shown below. It is an a.c. amplifier with a break frequency of about 30 Hz.



2. Use a double-beam CRO to monitor the signals at the input and output of the amplifier. Trigger on the output signal.

3. Use a signal generator to inject a signal at 100 Hz into the amplifier. Adjust its amplitude until the output signal of the amplifier has a peak value of 1.0 V.

4. Use the peak value of the input signal to calculate the gain of the amplifier at 100 Hz.

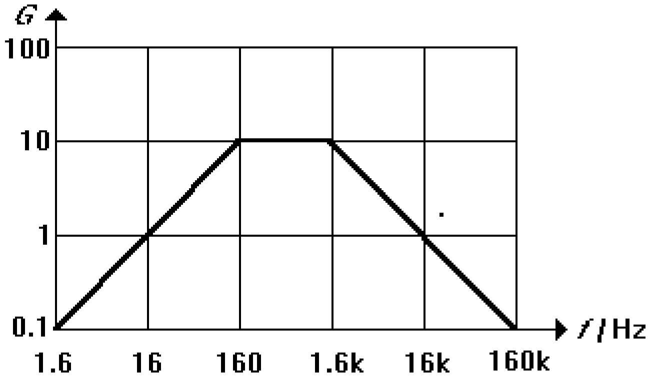
5. Repeat steps 3 and 4 at the following frequencies: 100 Hz, 1.0 kHz, 10 kHz and 100 kHz.

6. Use your results to plot a gain-frequency plot for the amplifier. Use the plot to estimate the unity-gain frequency of the op-amp.

7. Repeat the experiment with the 1 MΩ feedback resistor replaced with 100 kΩ.

Notch filter design

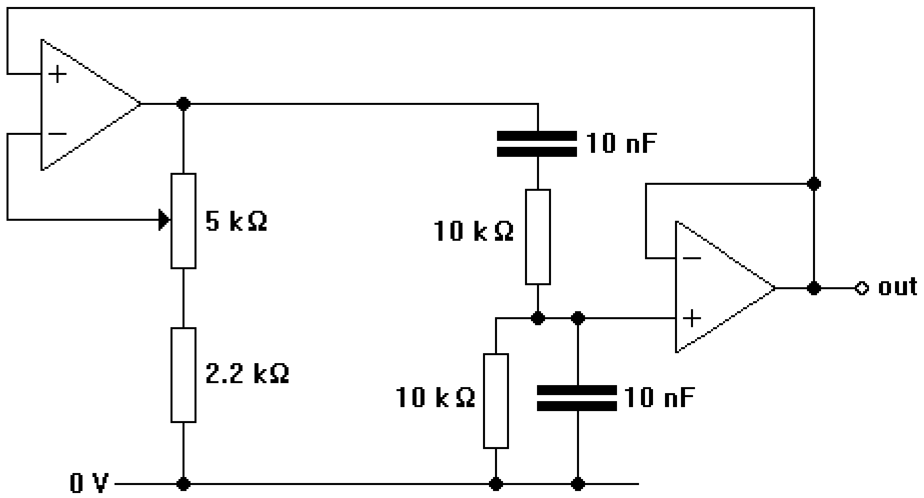
You are going to design a notch filter system which has the gain-frequency plot shown below



1. Design a bass cut filter with a high frequency gain of 5 and a break frequency of 160 Hz.
2. Assemble your circuit. Test its performance with a signal generator and a CRO.
3. Design a treble cut filter with a low frequency gain of 2 and a break frequency of 1.6 kHz.
4. Assemble your circuit. Test its performance with a signal generator and a CRO.
5. Feed the output of the bass cut filter into the treble cut filter to make the notch filter. Use a signal generator and a CRO to draw a gain-frequency plot for the filter.

A Wein oscillator

1. Assemble the sine wave oscillator shown below.



2. Connect an oscilloscope to the output. Adjust the potentiometer. If all is well, you should obtain a distorted sine wave with a frequency of about 2 kHz.

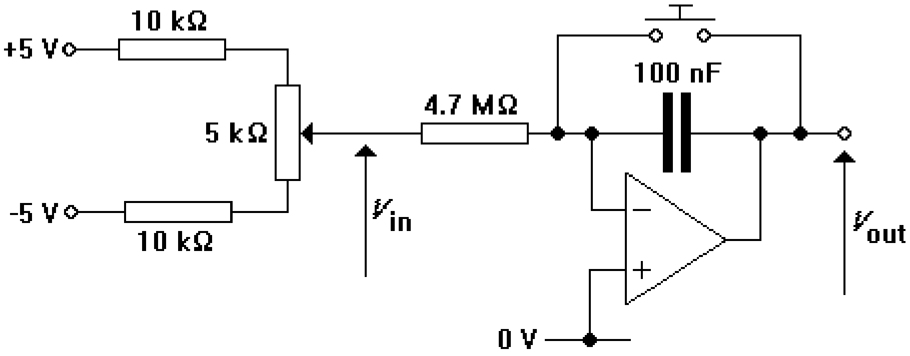
3. Adjust the potentiometer until the sine wave has the least distortion. Measure its period and calculate its frequency. Compare this with $1/2\pi RC$.

4. Try the effect of using 100 pF capacitors in the notch filter. How fast can you make the system oscillate by altering the resistor values?

5. How slow can you make the system oscillate? Start off with 100 nF and 1 MΩ in the notch filter.

Generating ramps

1. Assemble the ramp generator circuit shown below. Use a TL081.



2. Use a double-beam oscilloscope to look at V_{in} and V_{out}. Have 0 V in the centre of the screen. If all is well, V_{in} should cover the range +1 V to –1 V as you adjust the potentiometer.

3. Set V_{in} to –0.5 V. Press the switch and release it. Time how long it takes for V_{out} to change by 2.5 V. If all is well, it should be about 3 s.

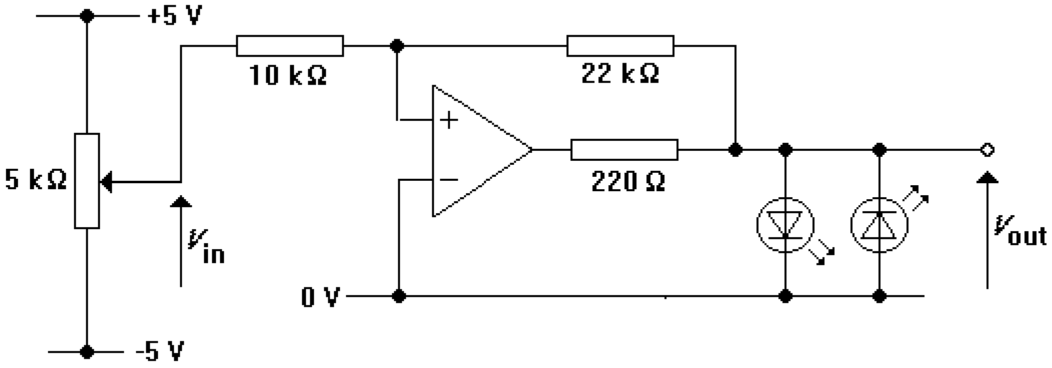
4. Use the formula below to calculate the time δt needed for V_{out} to change by 2.5 V. How well does it match the actual time?

$$\frac{\delta V_{out}}{\delta t} = -\frac{V_{in}}{RC}$$

5. Repeat steps 3 and 4 with V_{in} set at a variety of values between –1.0 V and +1.0 V.

Exploring a Schmitt trigger

1. Assemble the circuit shown below. The LEDs must have the same colour.



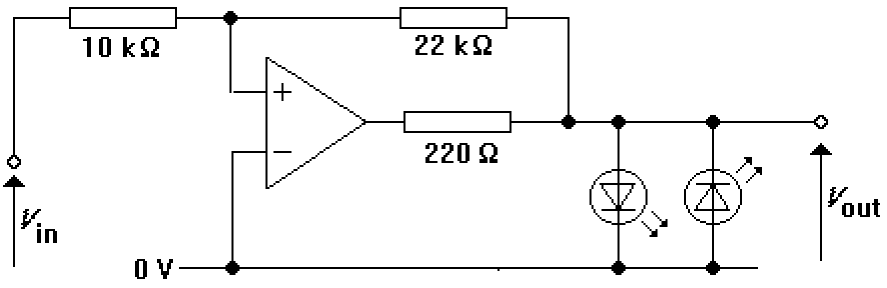
2. Use a double-beam oscilloscope to measure V_{out} and V_{in}. Twiddle the potentiometer. If all is well, V_{out} should swap between +2 V and –2 V.

3. Measure the trip points. Draw a characteristic graph for the circuit.

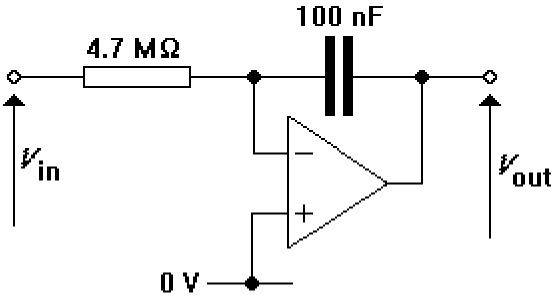
4 Adapt the circuit so that it becomes an inverting Schmitt trigger with trip points at approximately ± 1 V. Check that it operates correctly.

A triangle wave generator

1. Assemble the Schmitt trigger shown below. Test its operation by holding V_{in} at +5 V and –5 V in turn.



2. Assemble the ramp generator shown below. Test its operation by holding V_{in} at +5 V and –5 V in turn.

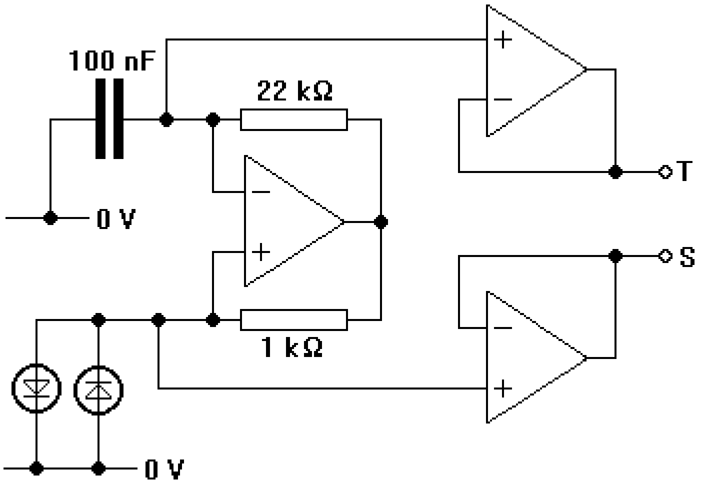


3. Now connect the two circuits together to generate a triangle wave. Use a double-beam oscilloscope to look at the input and output of the ramp generator. If all is well, the output should ramp back and forth between ±1 V with a frequency of 1 Hz.

4. Replace the 4.7 MΩ resistor with 4.7 kΩ. With the help of the oscilloscope, sketch graphs on a single set of axes to show the waveforms at the output and input of the ramp generator.

Mixing waveforms

1. Assemble the signal generator circuit shown below.



2. Use a double-beam oscilloscope to look at T and S. If all is well, both waveforms should have an amplitude of 0.7 V.

3. On a single set of axes, sketch the waveforms at T and S.

4. Sketch the waveform T – S.

5. Assemble a difference amplifier. Use it to generate the waveform T – S. Compare it with your prediction.

6. Now sketch the waveform 2(S + T).

7. Assemble a summing amplifier to generate 2(S + T). How does its output waveform compare with the one you drew in step 6?