

Exercises

1. The speedometer of a car's dashboard receives a signal in the $[0, 2]$ V range and shows speed values in the $[0, 200]$ km/h range. It will be connected to a sensor that measures speeds in the $[0, 50]$ m/s range, providing a reading in the $[0, 50]$ mV range. Design the signal conditioning needed to connect the sensor to the dashboard's speedometer.
2. A submarine has a sonar that creates a sound and detects its reflection by an object. The sound travels from the submarine to the object and back, and then is detected. The speed of sound in water is 1500 m/s.
 - (a) How is the distance d to the object related to the time t between the emission of the sound and the detection of its reflection?
 - (b) The sound detector that measures t returns a tension given by 100 mV per second. It will be connected directly to a display that receives signals in the $[0, 5]$ V range. What is the largest distance d that can be shown, before the display saturates?
3. An accelerometer outputs 14 mV per g , where $g = 9.8 \text{ m/s}^2$. Design a signal conditioning to convert this into 0.25 V per m/s^2 .
4. A quadcopter has a sensor to measure its height. The maximum frequency of this signal is 10 Hz. There is noise at frequencies of 1 kHz and higher. Design a filter with at least 37 dB attenuation for noise, while letting at least 99% of the signal pass.
5. A sensor reads a signal given by $y(t) = \cos(10t)$. A power amplifier introduces noise estimated as $d(t) = 0.5 \cos(10^4 t)$. In order to reduce the amplitude of the noise to 0.01, the filter in Figure 11.1 was employed.
 - (a) The resistance is $R = 10 \text{ k}\Omega$ and the capacitor is $C = 6 \text{ }\mu\text{F}$. Explain why the filter is not suitable for its purpose.
 - (b) What values of R and C would be suitable?
6. Consider the filter in Figure 11.2.
 - (a) Find transfer function $\frac{V_{out}(s)}{V_{in}(s)}$.
 - (b) What kind of filter is this?
 - (c) What values of R_1 , R_2 , C_1 and C_2 would you use to obtain a cut-off frequency of 100 Hz?
 - (d) Plot the resulting Bode diagram.
 - (e) Replace resistors by capacitors and vice-versa, and answer again all the questions above.
7. An 8-bit AD converter receives values in the in the $[0, 10]$ V range.
 - (a) What is the converter's input when its output is 10101001?
 - (b) What is the converter's input when its output is 01010111?
 - (c) What is the converter's output when its input is 3 V?

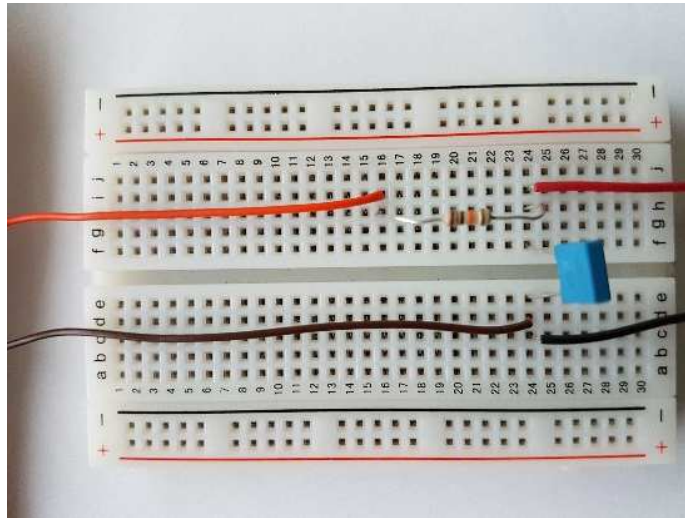


Figure 11.1: Circuit with the filter of Exercise 5. The sensor is connected to the left of the breadboard, and the filtered signal is read to the right.

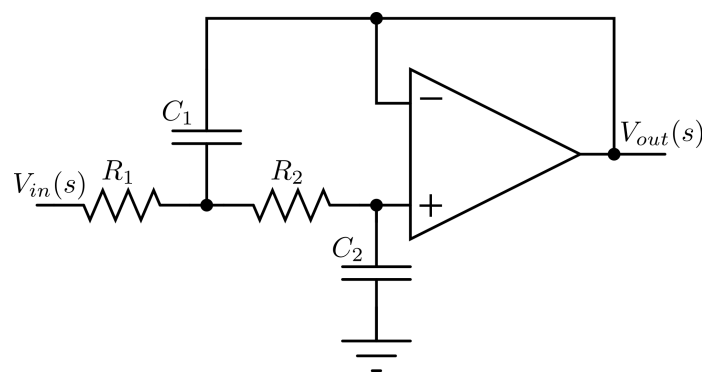


Figure 11.2: Circuit with the filter of Exercise 6.

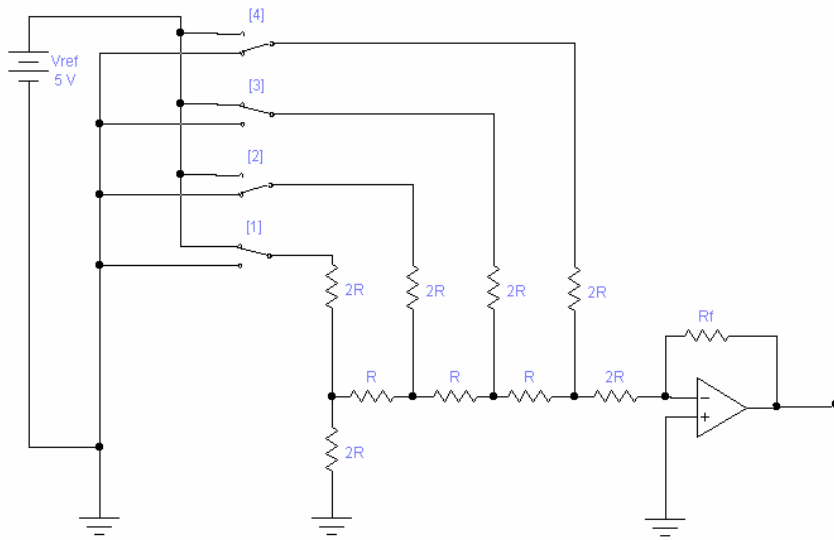


Figure 11.3: DA converter of Exercise 8.

- (d) What is the converter's resolution?
8. Consider the DA converter in Figure 11.3.
- (a) What is the converter's output when its input is 1001?
- (b) What is the converter's output when its input is 0101?