Equivalent Resistance and High-Pass Filters

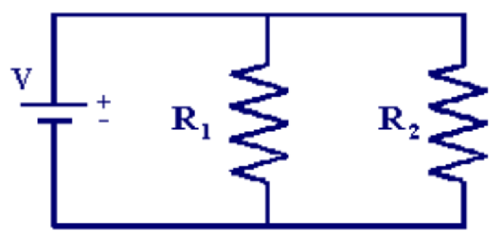
Analog Electronics, 2026-04-10

1. From Nik, Theory of Equivalent Resistance

Hey guys! This may seem simpler than what we've been working on, but I really want to make sure as we move on to more applied usages that I have a fully solid understanding of first principles.

On a circuit powered by a 9V battery, the two resistors below are valued at:

- R_1=4 kΩ
- R_2=6 kΩ



I. Using only Ohm's law (not the parallel resistance formula) calculate the current through each resistor.

II. Determine the total current drawn from the battery.

III. Consider: $I_{total} = V/R_{eq}$

   A. Use results from earlier questions to calculate R_{eq}.

   B. Show algebraically that: $1/R_{eq} = 1/R_1 + 1/R_2$

IV. If I claimed that adding another resistor in parallel would increase total resistance, how could you use Ohm's law to prove me wrong?'

V. If there were hypothetically a circuit in which the resistance is infinite, what would happen to the current? Use Ohm's law to support your answer.

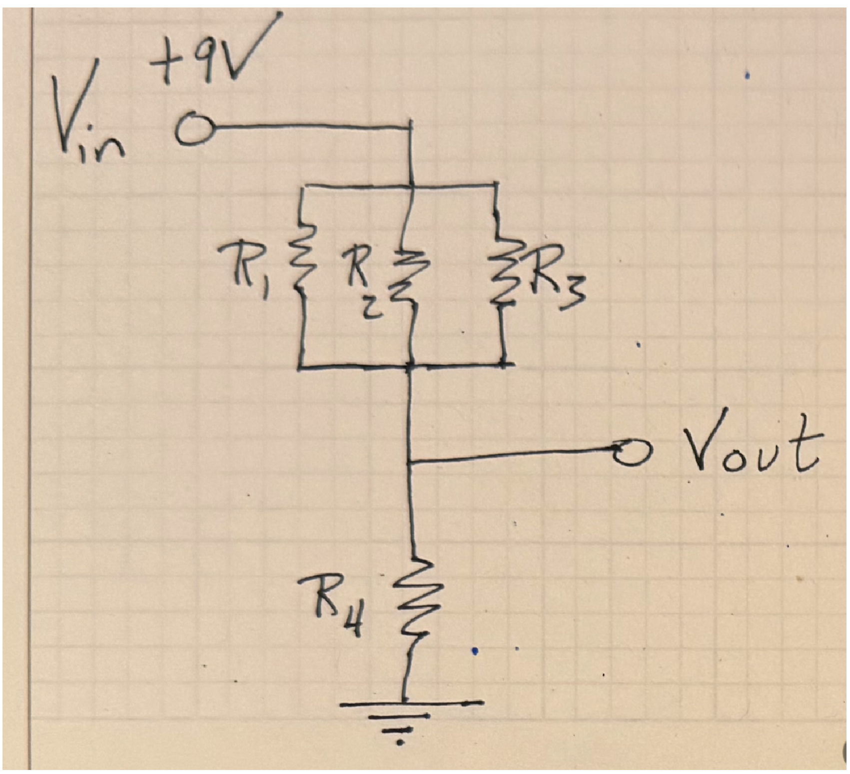
2. From Grisha, Reducing Voltage at a Speaker

Grisha has a 20 watt speaker that goes off every morning in his plastic goose. It is supposed to be powered by a 12v power supply, but Grisha only has a 15v power supply, which is too much voltage for the speaker. What resistance resistor can he add in series with the speaker to deliver 12v to the speaker? What power rating will it need to be rated for? How many 10 ohm resistors in parallel with each other could he use instead of buying this special resistor? What power rating would they need?

Assume the speaker has 8Ω of internal resistance.

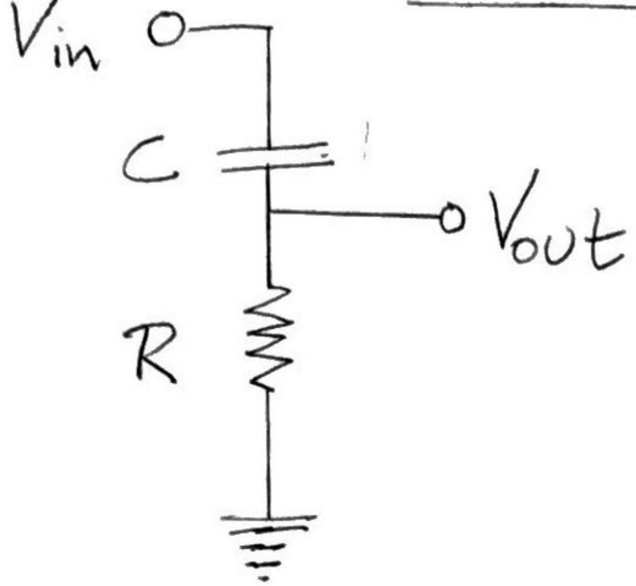
3. From Victoria, A Complex Series and Parallel Resistance Problem

Calculate V_{out} from V_{in} = 9 V if R_1 = 6 kΩ, R_2 = 40 kΩ, R_3 = 1 kΩ, and R_4 = 147 kΩ.



4. From Brian, High Pass Filter, On Following Pages

The High-Pass Filter



As in problems 7 and 8 on the last problem set, weirdly, for input voltages of a definite frequency the capacitor can be thought of as having a resistance at 50Hz

$$R' = \frac{1}{2\pi f C}$$

$$= \frac{1}{2\pi \cdot 50Hz \cdot 100nF} = 31831 \Omega$$

$\approx 30k\Omega$ (rounded to one sig fig)

And at 5000Hz

$$R'' = \frac{1}{2\pi f C} = \frac{1}{2\pi \cdot 5000Hz \cdot 100nF} \approx 300\Omega$$

This time the formula that relates V_{in} and V_{out} is

use 10V

50Hz case

(a) $V_{out} = V_{in} \frac{R}{\sqrt{R^2 + R'^2}}$

=

Use $R = 3000 \Omega$ in (a) and (b)

again, use 10V

(b) $V_{out} = V_{in} \frac{R}{\sqrt{R^2 + R''^2}}$

=

If all went well, you'll get that the high-frequency input was not attenuated as much as the low-frequency input. "High Pass."

In[37]:=
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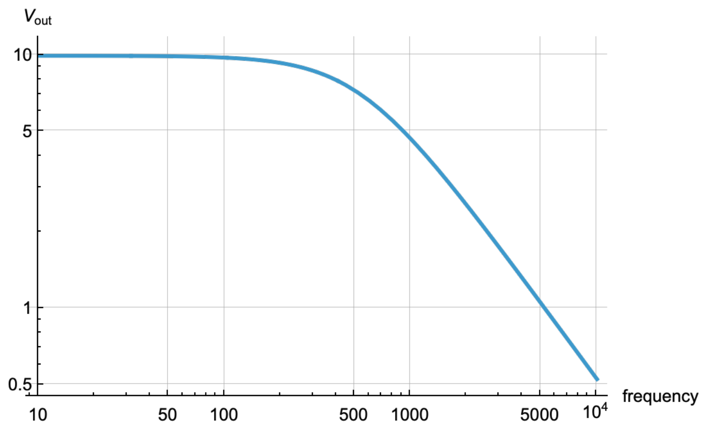
r = 3000;
vIn = 10;
c = 100 × 10^-9;
```

Frequency Response in Low-Pass Arrangement

In[40]:=
$$\text{vOutLowPass[f\_] := vIn}\ \frac{\frac{1}{2\,\text{Pi}\,f\,c}}{\text{Sqrt}\left[r^2 + \left(\frac{1}{2\,\text{Pi}\,f\,c}\right)^2\right]}$$

In[41]:=
```
LogLogPlot[vOutLowPass[f], {f, 10, 10 000},
 GridLines → Automatic, AxesLabel → {"frequency", "Vout"}]
```

Out[41]=

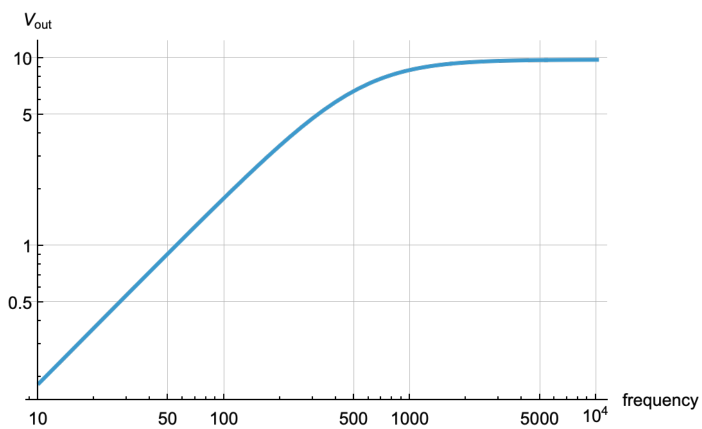


Frequency Response in High-Pass Arrangement

In[42]:=
$$\text{vOutHighPass[f\_] := vIn}\ \frac{r}{\text{Sqrt}\left[r^2 + \left(\frac{1}{2\,\text{Pi}\,f\,c}\right)^2\right]}$$

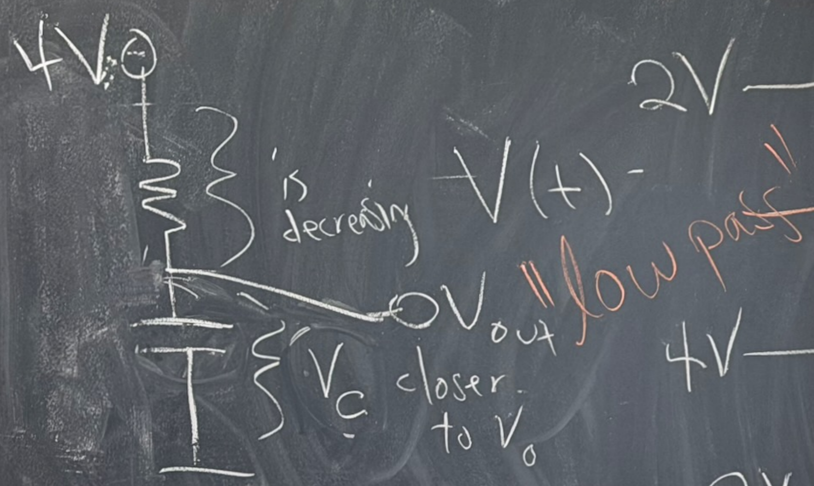
In[43]:=
```
LogLogPlot[vOutHighPass[f], {f, 10, 10 000},
 GridLines → Automatic, AxesLabel → {"frequency", "Vout"}]
```

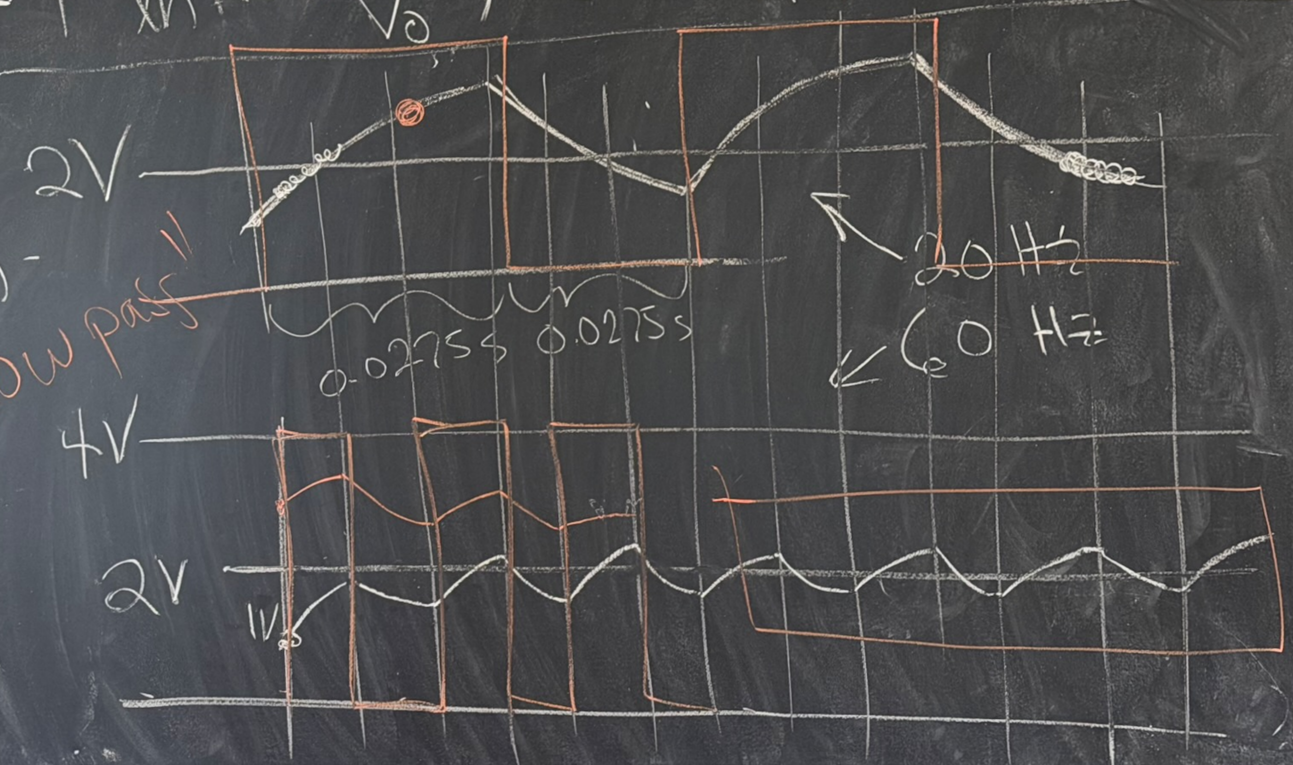
Out[43]=



$$t = -\tau \ln\left(1 - \frac{V(t)}{V_0}\right)$$

charging $V(t) = V_0(1 - e^{-t/\tau})$





$\tau = RC$