- Feedback voltage circuit (V_{ref})

$R_1 = 11.4k\Omega \quad R_2 = 1k\Omega$

1) $$V_{out} = (V_f - V_{ref}) \times \frac{R_1 + R_2}{R_2} + V_{ref}$$

$$V_{out} = \frac{R_1+R_2}{R_2} \cdot V_f - \frac{R_1}{R_2} V_{ref} = 15.3 - 11.4\, V_{ref}$$

$$V_{out}|_{min} = 12V \rightarrow V_{ref}|_{max} = 0.29V$$ ← small :/

2) Solution: greater $V_{out}|_{max}$

$V_{out}|_{max} = 42V \qquad R_1 = 33k\Omega \qquad R_2 = 1k\Omega$

$V_{out} = 42 - 33\, V_{ref} \qquad V_{out}|_{min} = 12V \rightarrow V_{ref}|_{max} = 0.91V$

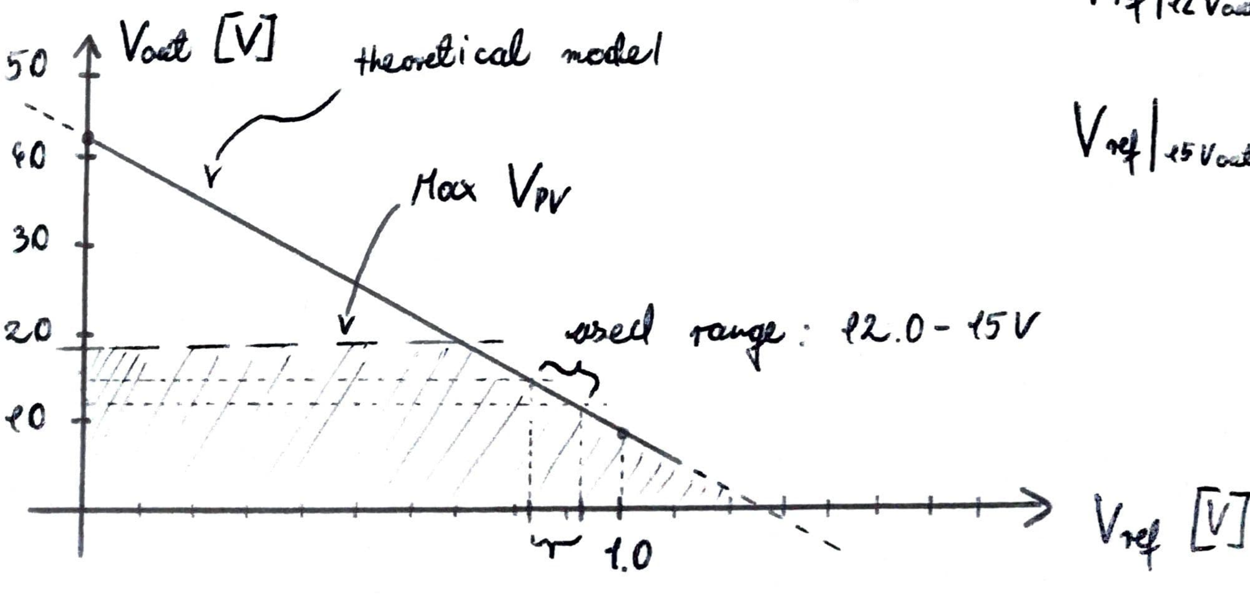
$V_{out} = 0V \rightarrow V_{ref} = 1.27V$

- Attention: Very high input resistance !
- Input R of LM5276 > few MΩ ← no problem

3) Graph of $V_{out}(V_{ref})$ for this configuration

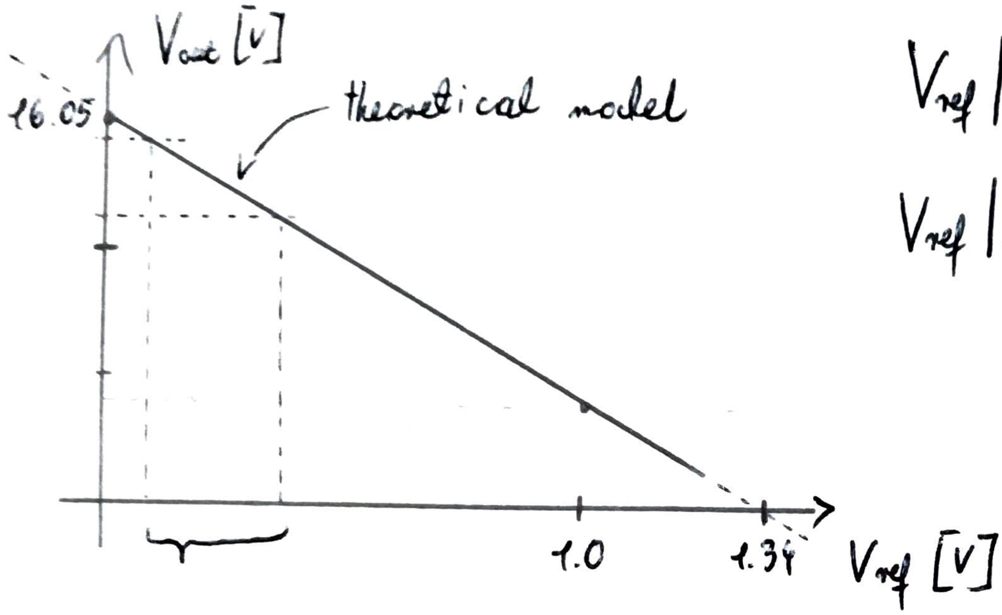
$V_{ref}|_{12V_{out}} = 0.91V$

$V_{ref}|_{15V_{out}} = 0.82V$



4) Final choice $R_1 = 1\cancel{7}2\,k\Omega$ $R_2 = 1\,k\Omega$

$$V_{out} = \frac{R_1 + R_2}{R_2} V_+ - \frac{R_1}{R_2} V_{ref} = \cancel{1182}\ 16.05 - 12\,V_{ref}$$



$V_{ref}\big|_{12\,V_{out}} = 0.338\,V$

$V_{ref}\big|_{15\,V_{out}} = 0.086\,V$

$dV = 0.25\,V$

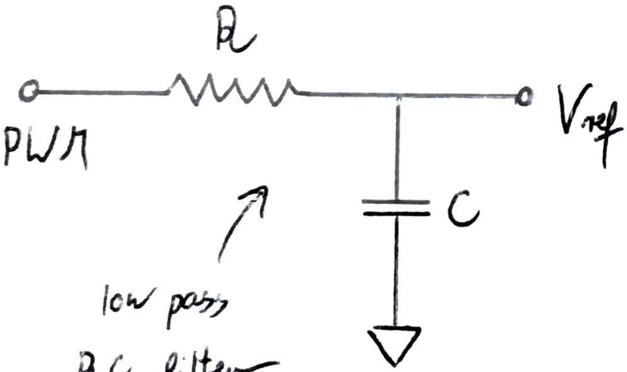
$dV = 5\%$ DC (duty cycle)

5) RC filter design

$$f_c = \frac{1}{2\pi RC}$$

$f_{PWM} = 7\,800 \approx 8\,kHz$

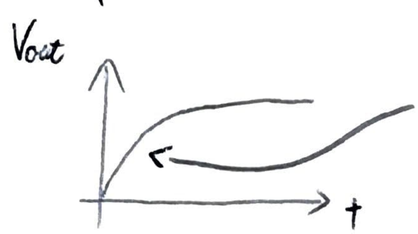
$/ f_{PWM} = 62.5\,kHz$



low pass RC filter (passive)

$R = 33\,k\Omega$ $C = 10\,\mu F$

$f_c = 0.48\,Hz$



slow response to change ~0.5 s

- lower Arduino PWM frequencies (e.g. 100 - 500 Hz) gives Vout closer to $V_{in} \times DC$, however for frequencies < 100 Hz large voltage ripple (+/- 10 mV) can be observed

5) Further tests:

- Final thoughts:

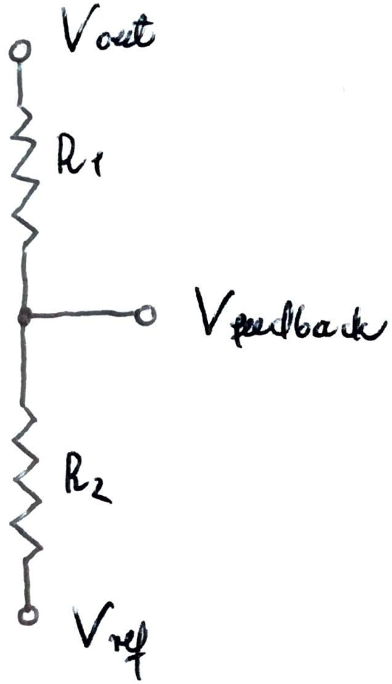
1) 490 Hz as PWM frequency gives the best results for generating voltages $0 < V_{out} < 500\,mV$;

2) The best RC filter for this frequency and voltages turned out to be $R = 33\,k\Omega$, $C = 10\,\mu F$, $f_c = 0.48\,Hz$, and response to change $0 \rightarrow 500\,mV$ faster than a second;

3) Before the final assembly, calibration is necessary:

- V_{out} for 20 DC settings, and vice versa DC set. for 20 given V_{out}

m



$$V_{feedback} = (V_{out} - V_{ref}) \cdot \frac{R_2}{R_1 + R_2} \Rightarrow$$

for (1)

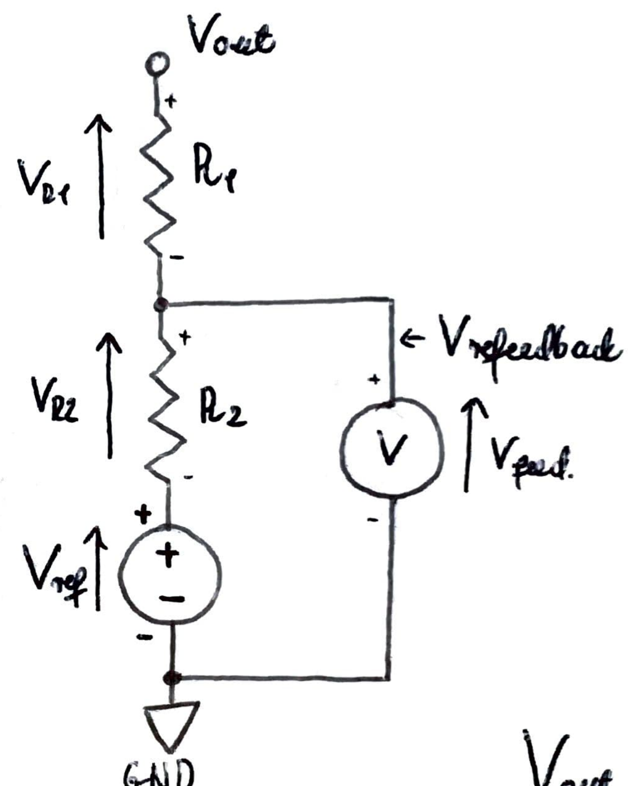
$$V_f = \cancel{9.4} \times (V_{out} - V_{ref})$$

$$\frac{1}{10.4} = 0.096$$

$$V_{out} = \frac{R_1 + R_2}{R_2} \cdot V_{feedback} + V_{ref}$$

Corrected

Feedback Voltage



$$\begin{cases} V_f = V_{R2} + V_{ref} \\ V_{R2} = (V_{out} - V_{ref}) \cdot \dfrac{R_2}{R_1 + R_2} \end{cases}$$

$$\Downarrow$$

$$V_f - V_{ref} = (V_{out} - V_{ref}) \cdot \frac{R_2}{R_1 + R_2}$$

$$(V_f - V_{ref}) \cdot \frac{R_1 + R_2}{R_2} + V_{ref} = V_{out}$$

$$V_{out} = (V_f - V_{ref}) \times \frac{R_1 + R_2}{R_2} + V_{ref}$$

1) $R_1 = 4.7 \times 2 = 9.4\ k\Omega$ $(9.2\ k\Omega)$

$R_2 = 1\ k\Omega$

$$V_{out} = \frac{\overset{10}{\cancel{9}}.4}{1} \times 1{,}235 + V_{ref}$$

$$V_{out} = 12{,}\overset{84}{\cancel{6}} + V_{ref}$$