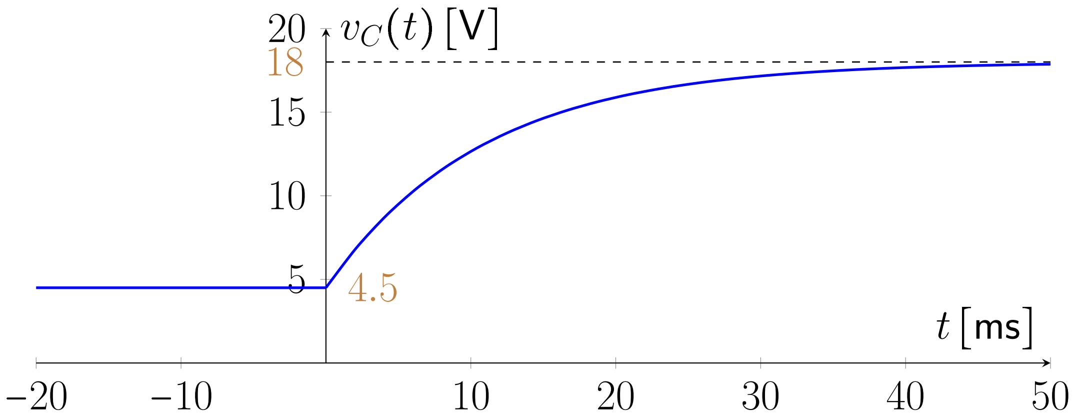
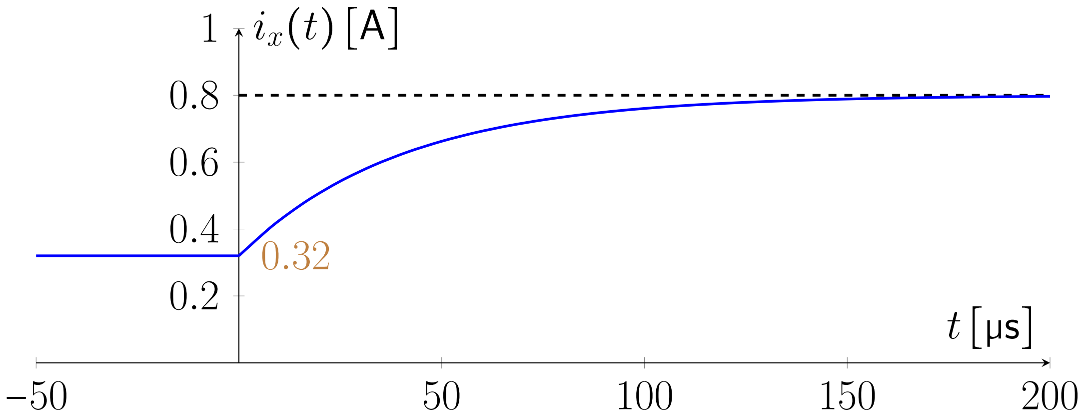
Seminar - 11$^{\text{th}}$ week - results

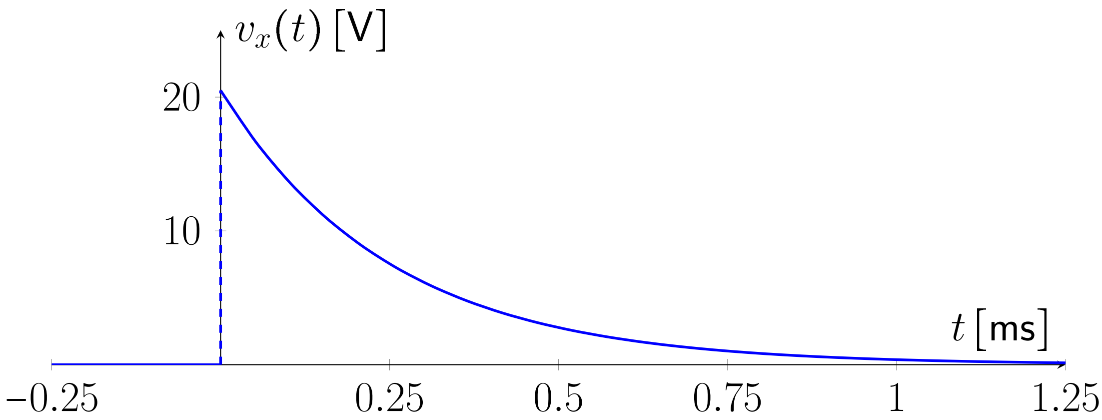
1. $v_C(t) = [4.5 - 18]e^{-\frac{t}{0.0108}} = 18 - 13.5\,e^{-92.59t}$



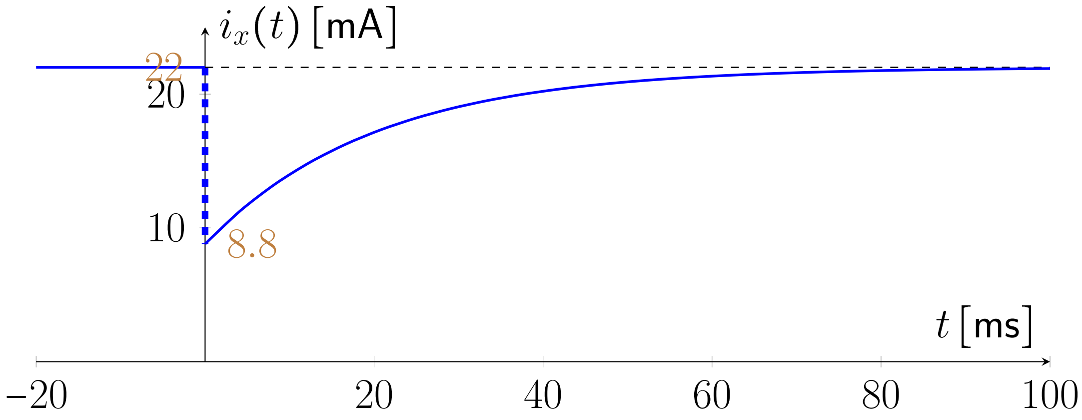
2. $i_x(t) = [0.32 - 0.8]10^{-\frac{t}{4\cdot e^{-5}}} + 0.8 = 0.8 - 0.48\,e^{-25000t}$



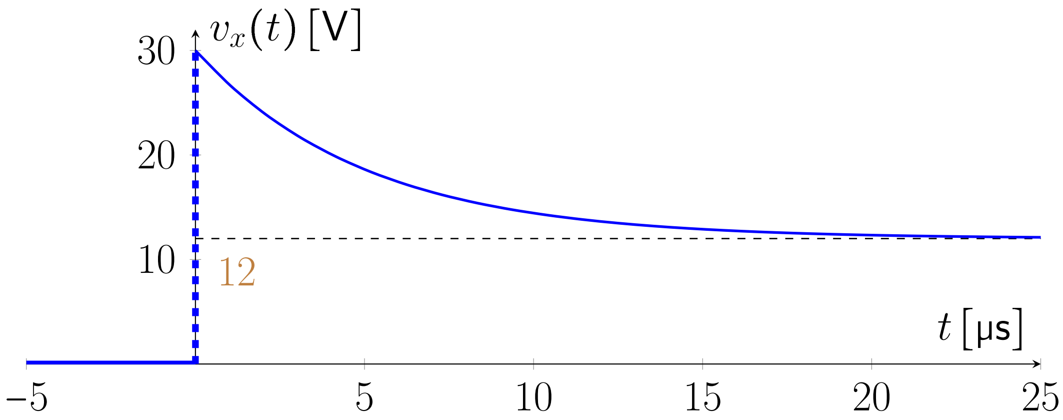
3. $i_L = [-25 + 4.5]e^{-4000t} - 4.5\,[\text{mA}]$,
   $v_x = 20.5\,e^{-4000t}\,[\text{V}]$



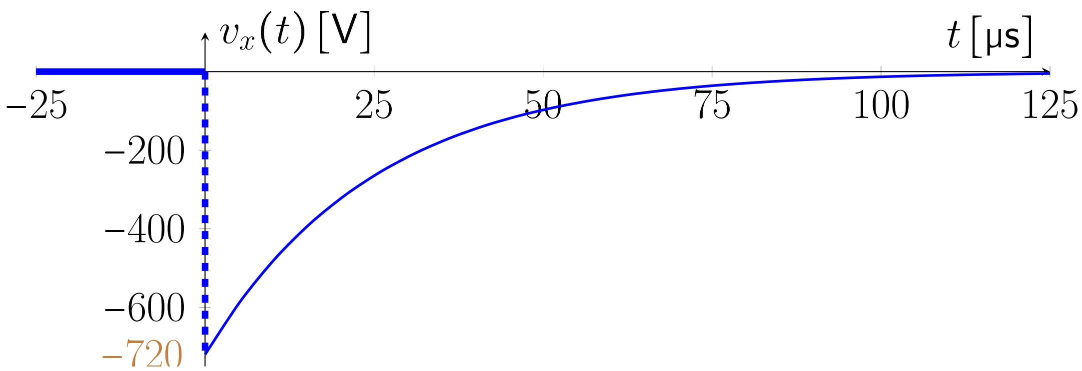
4. $v_C(t) = [8.8 - 22]e^{-50t} + 22 = 22 - 13.2\,e^{-50t}$ [V],
$i_x(t) = 22 - 13.2\,e^{-50t}$ [mA]



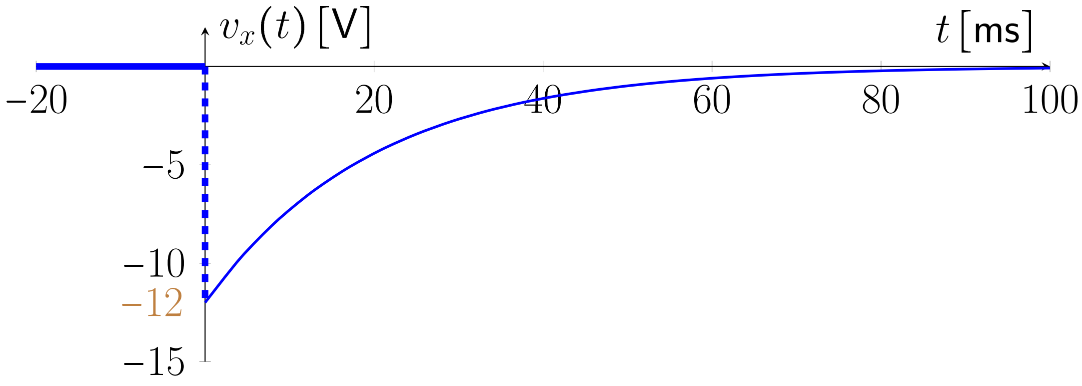
5. $i_L(t) = 15\,(1 - e^{-200000t})$ [mA],
$v_x(t) = [30 - 12]e^{-200000t} + 12 = 12 + 18\,e^{-200000t}$ [V]



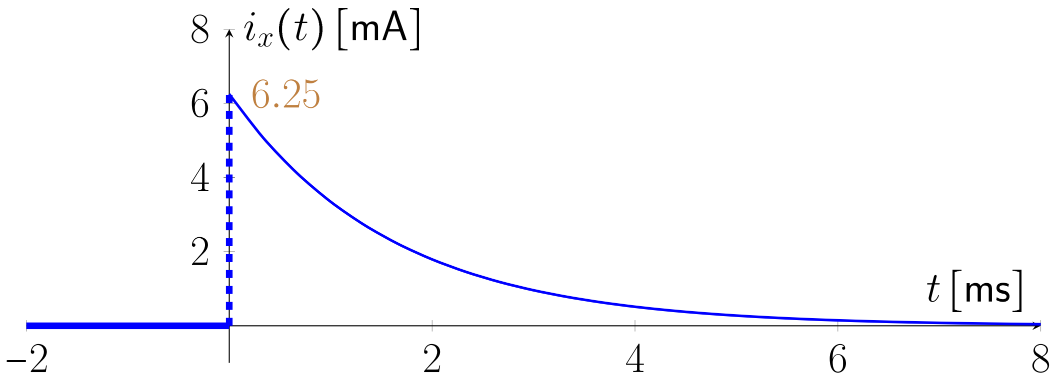
6. $i_L(t) = [10 + 50]e^{-40000t} - 50$ [mA].
$v_x(t) = -720e^{-40000t}$ [V]



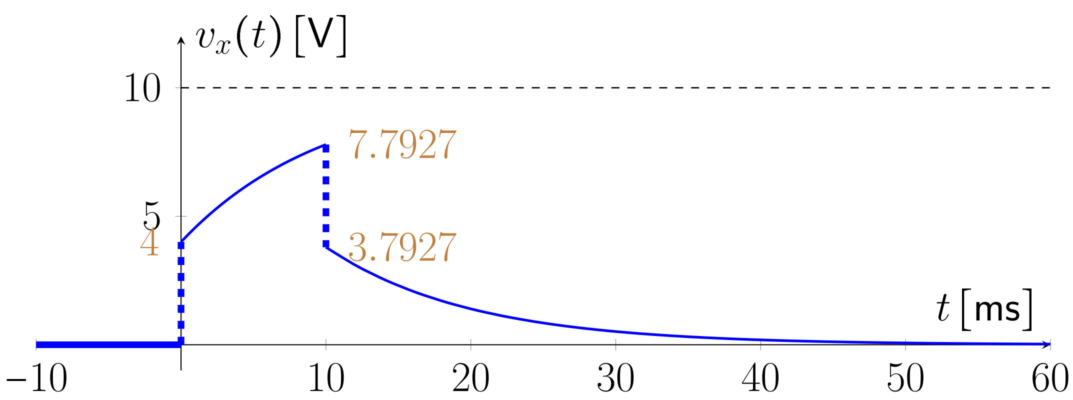
7. $v_x(t) = -12\,e^{-50t}$ [V]

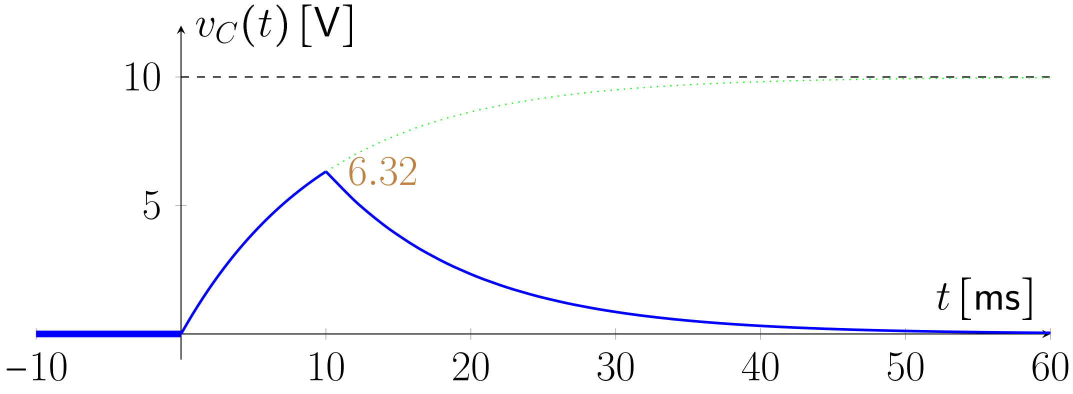


8. $v_C(t) = -10\, e^{-625t}$ [V],
   $i_x(t) = 6.25\, e^{-625t}$ [mA]

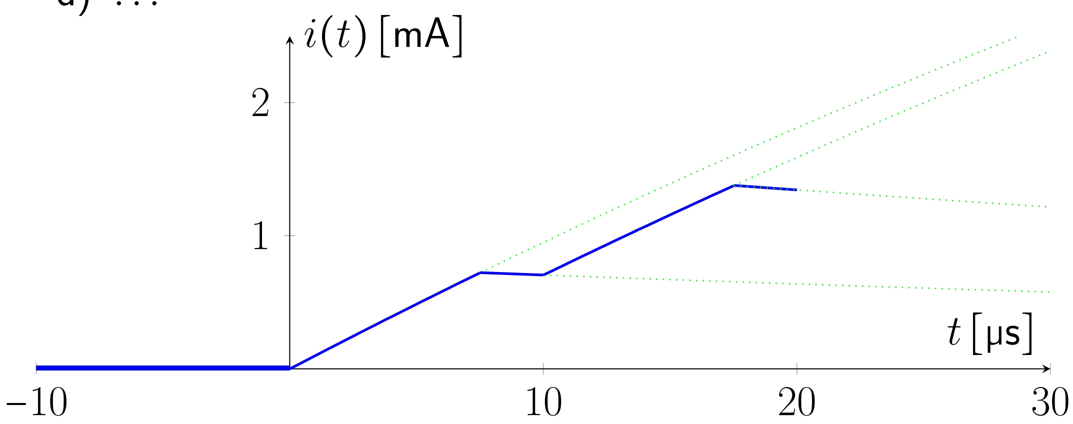


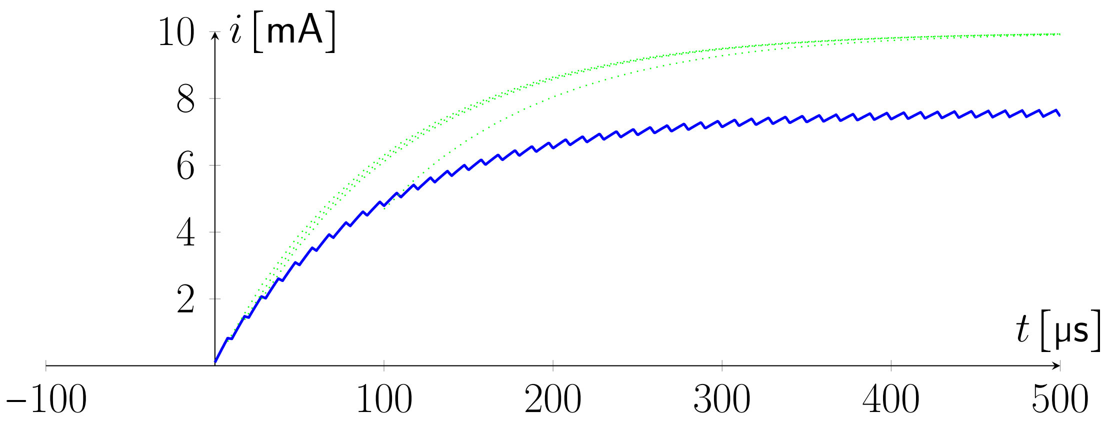
9. In the interval $t \in \langle 0, 10)$ ms:
   $v_C(t) = 10\,(1 - e^{-100t})$ [V],
   $v_x(t) = 10 - 6\, e^{-100t}$ [V].
   At time $t \geq 10$ ms:
   $v_C(t) = 6.32\, e^{-100t}$ [V],
   $v_x(t) = 3.7927\, e^{-100t}$ [V] (for independent transient, so the new time origin is at $t = 0$), or $v_x(t) = 3.7927\, e^{-100(t-0.01)}$, if we have common time origin for both transients.

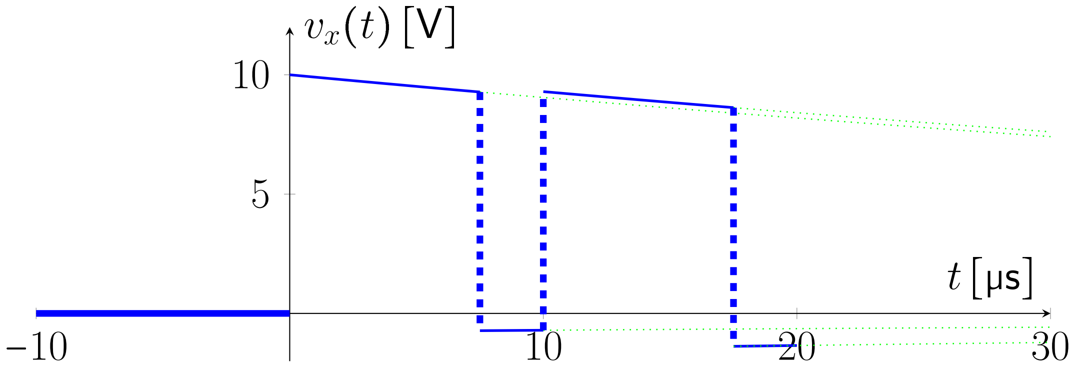




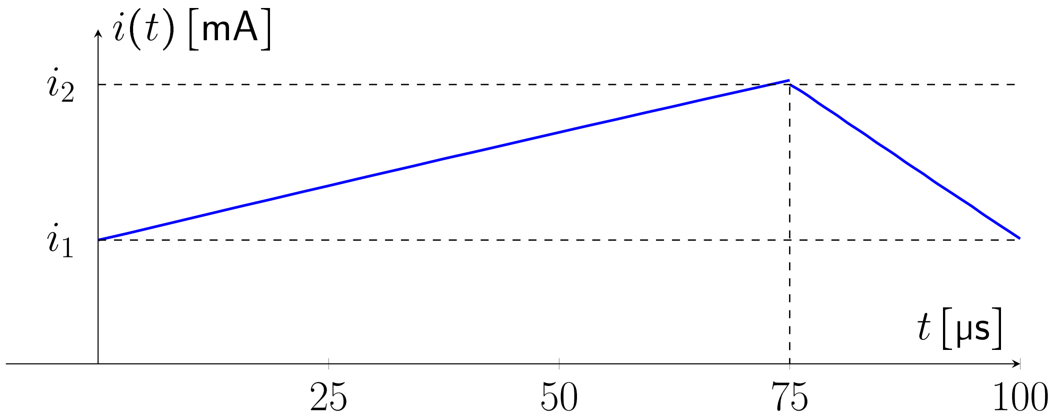
10. a) $t \in \langle 0, 7.5)$ μs:
$i(t) = 10(1 - e^{-10000t})$ [mA]
$v_x(t) = 10\, e^{-10000t}$ [V]
b) $t \in \langle 7.5, 10)$ μs:
$i(t) = 0.7226\, e^{-10000(t-0.0000075)}$ [mA]
$v_x(t) = -722.6\, e^{-10000(t-0.0000075)}$ [mV]
c) $t \in \langle 10, 17.5)$ μs:
$i(t) = 10 - 9.295\, e^{-10000(t-0.00001)})$ [mA]
$v_x(t) = 9.295\, e^{-10000(t-0.00001)})$ [V]
d) ...







Mean value after long time ($t \gg 0.3\,\text{ms}$):

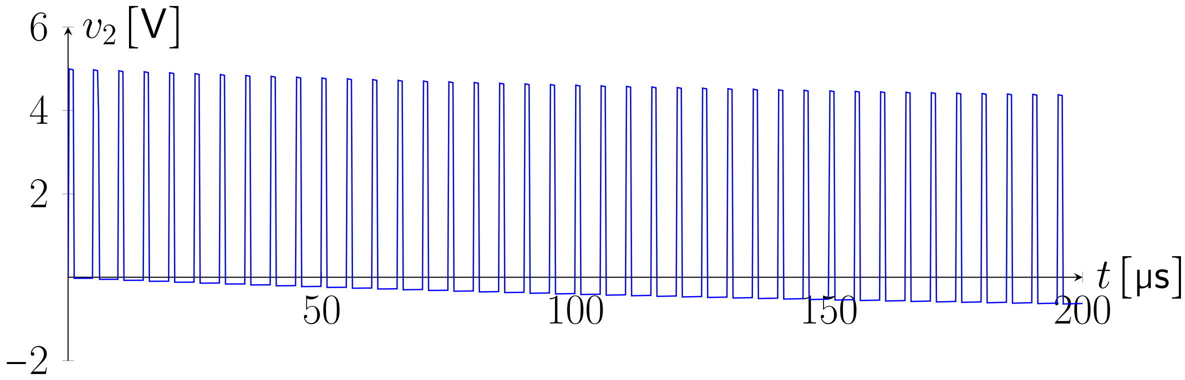


$i(7.5\,\mu\text{s}) = i_2 = (i_1 - 10)\, e^{-0.075} + 10\, [\text{mA}]$
$i(2.5\,\mu\text{s}) = i_1 = i_2\, e^{-0.075}\, [\text{mA}]$

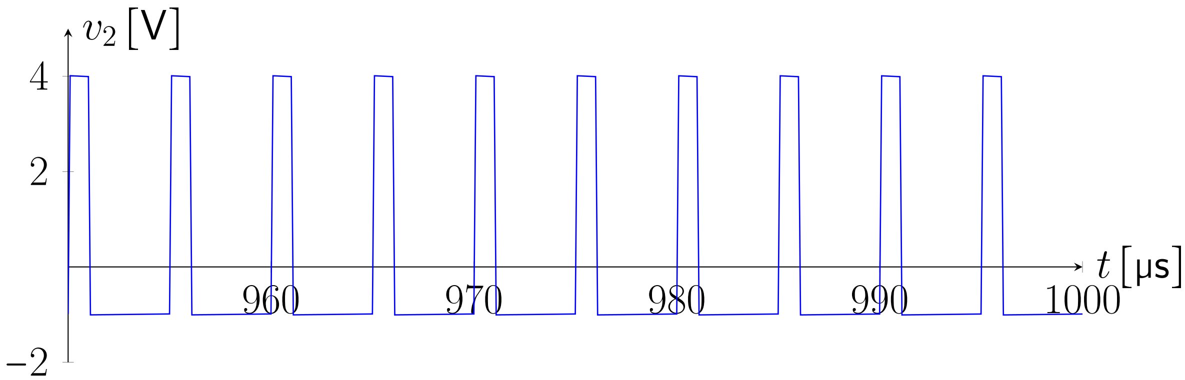
$$\begin{bmatrix} e^{-0.075} & -1 \\ -1 & e^{-0.025} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 10\, e^{-0.075} - 10 \\ 0 \end{bmatrix}$$

$i_1 = 7.405\,\text{mA}$, $i_2 = 7.593\,\text{mA}$, $i_{mean} = 7.499\,\text{mA}$ (or $D \cdot 10 = 7.5\,\text{mA}$). Mean value of current is directly related to duty cycle – this principle is used in the DC-DC converters and LED current regulators.

11. $t \in \langle 0, 200)$ µs:

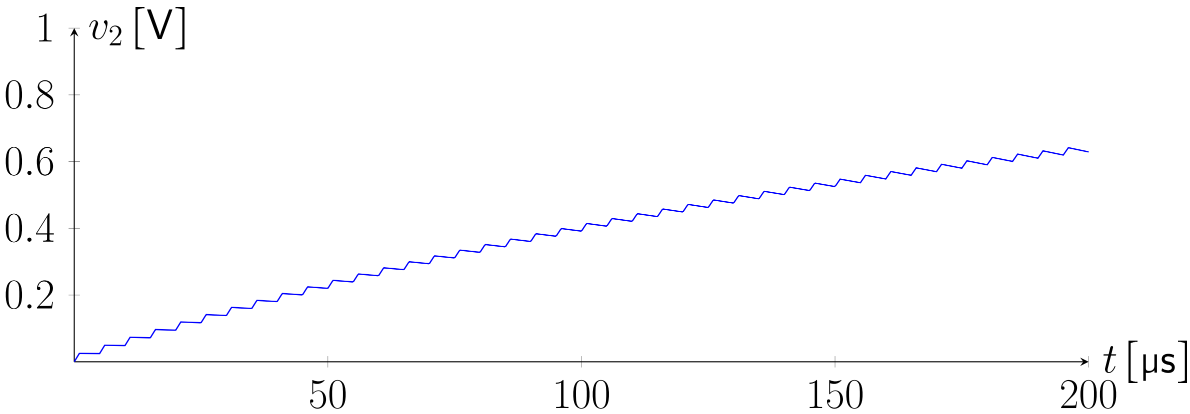


$t \in \langle 950, 1000)$ µs:

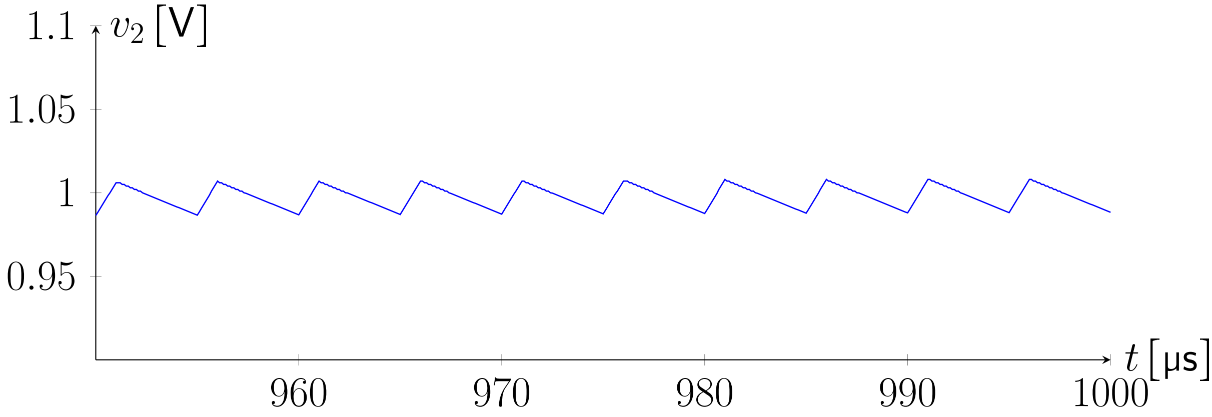


Since $T \ll \tau$, the capacitor in the circuit doesn't have time to be fully charged nor discharged. Mean value of its voltage is $V_{source} \cdot D = 5 \cdot 0.2 =$ 1 V. The voltage on resisor is, according to the KVL, $v_R = v - v_C$, which is (ommiting small exponential variations due to transients) $5 - 1 =$ 4 V, or $0 - 1 =$ −1 V, depending whether the source voltage is $v =$ 5 V, or $v =$ 0 V in a given moment.

12. $t \in \langle 0, 200)$ µs:



$t \in \langle 950, 1000 \rangle$ µs:



Since $T \ll \tau$, the capacitor in the circuit doesn't have time to be fully charged nor discharged. Mean value of its voltage is $V_{source} \cdot D = 5 \cdot 0.2 = 1\,\text{V}$.

13. The oscillator is obviously running. It seems that in the circuit is a transient, where $\tau > T$. First, verify input capacitance of the oscilloscope probe. It can have capacitance as many as 200 pF, which is usually much more than maximum output load capacitance – check the datasheet of the oscillator. It is the most common reason. Try different probe. If probe capacitance is far below the oscillator load capacitance, check input capacitances of all circuits, connected to the oscillator. If it is still below maximum oscillator load capacitance, measure PCB trace capacitance (or, at least, measure its length; the capacitance can be roughly 1 – 2 pF per cm).