Exercise:
First Simulations

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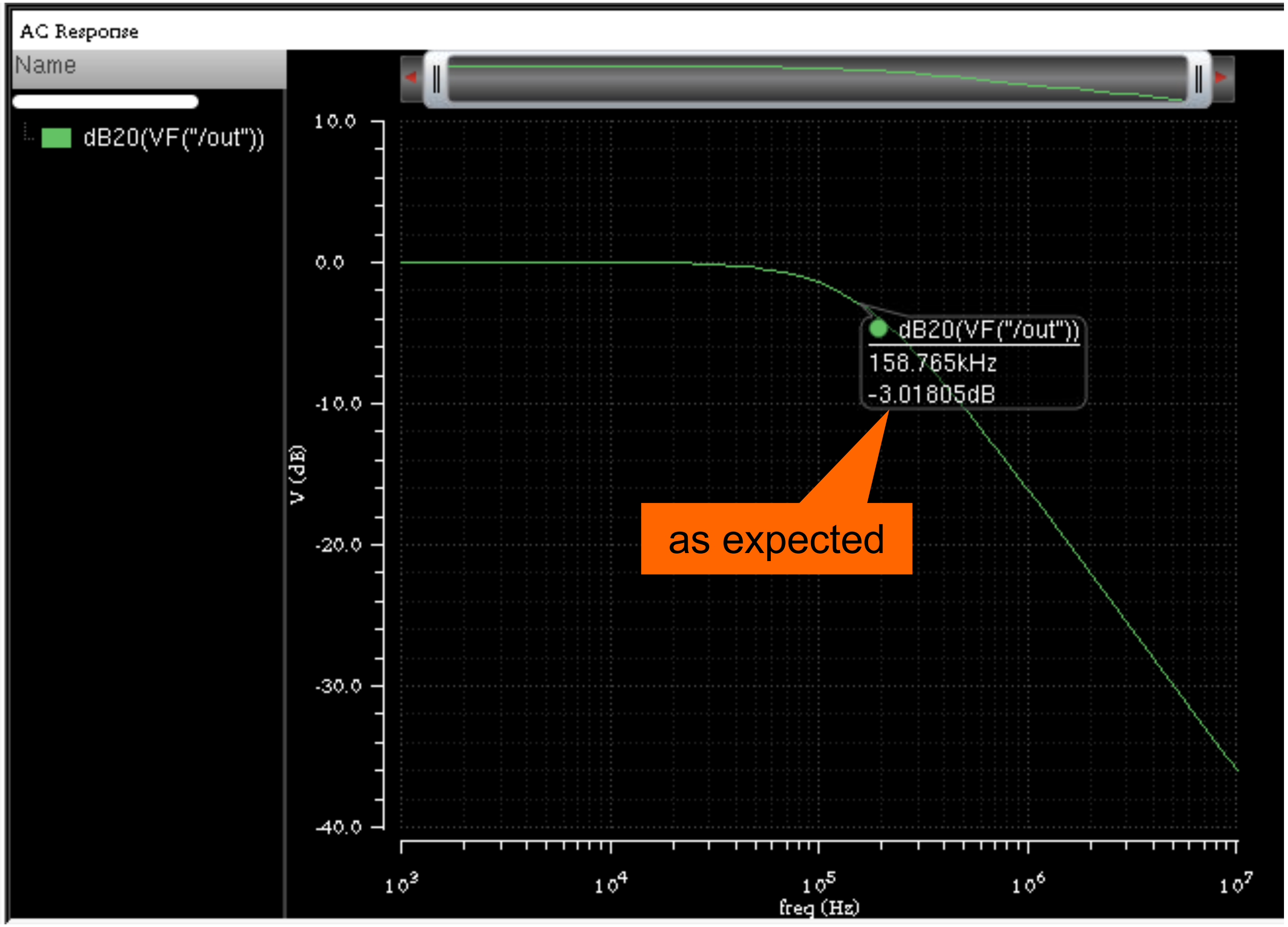
Exercise 1: High Pass – AC Analysis

- Create a HighPass circuit
  - Use a voltage source, ground symbol, res (1k), cap (1n)
  - Make sure the voltage source has 'AC Magnitude' set to 1
- What is the corner frequency of your circuit (in Hertz!) ?
- Chose an AC analysis with frequency span 2-3 orders of magnitude around the corner.
- Plot the Magnitude of the output
- Check that the -3dB point is **exactly** what you expect!
- Change component values, predict the effect and simulate.
- Make the circuit more complicated (add more Rs and Cs)

Solution 1: High Pass – AC analysis

- RC = 1k×1n = 1µ → ω = 1 MHz → ν = 1/2π MHz = 159 kHz



Exercise 2: High Pass & Rectangular Pulse

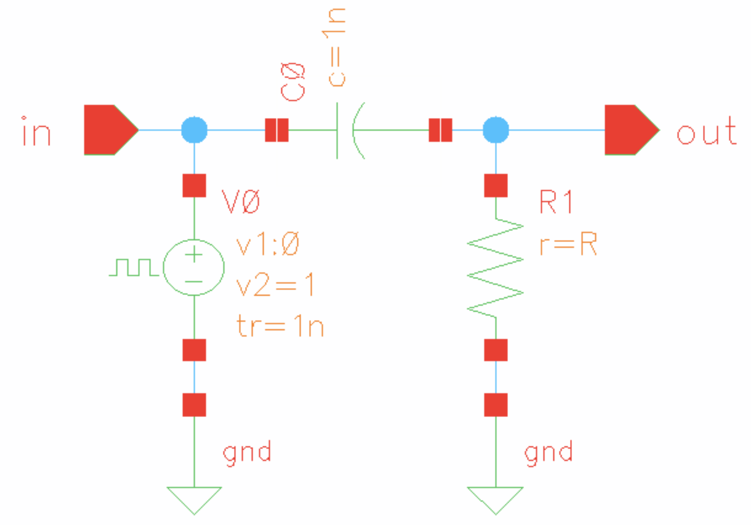
- Now use a rectangular pulse generator (vpulse)
  - Set the various parameters of vpulse
  - Chose the frequency much slower than the RC time

  - How does the output waveform look like ?
  - When has the signal decreased to 1/e of the input step?
  - Is this what you expect from the component values?

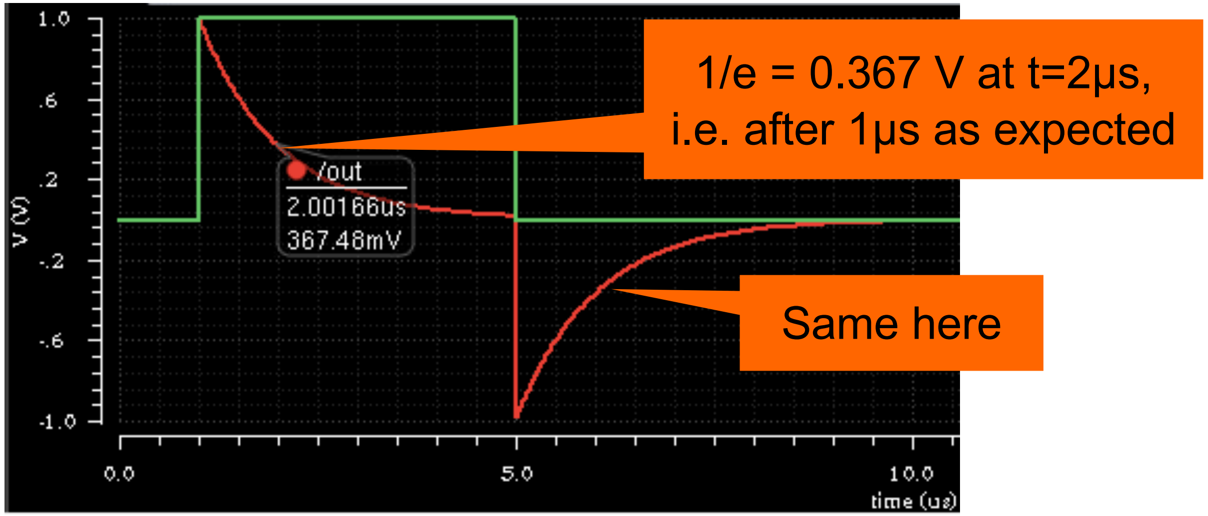
  - Double the resistor and check what happens!

Solution 2: High Pass & Rect

- Circuit:

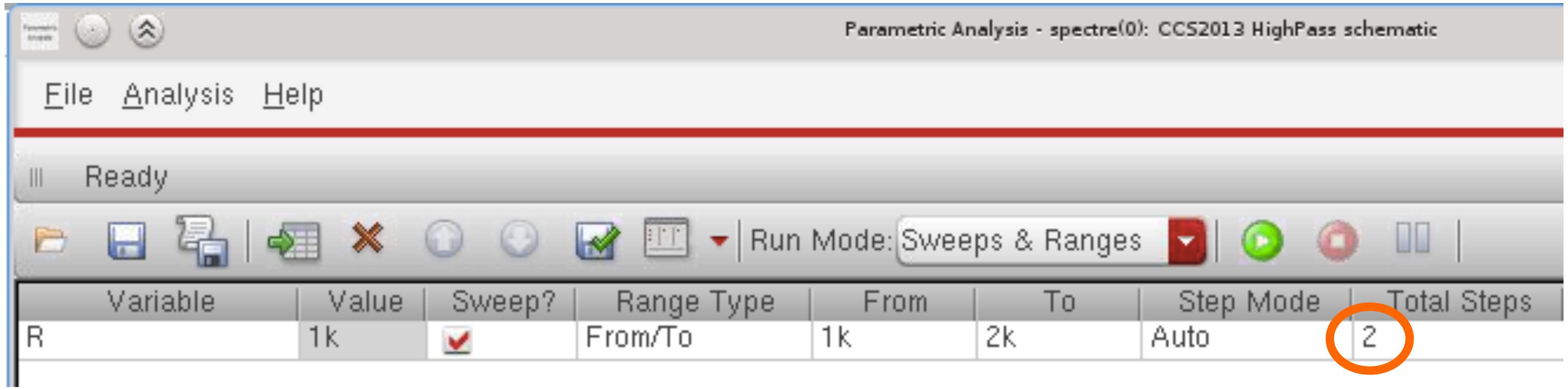


- For R = 1k, RC = 1k × 1n = 1µ (⇔ ω=1 MHz)
  → Use 10 µs period. Edge starts here at 1µs

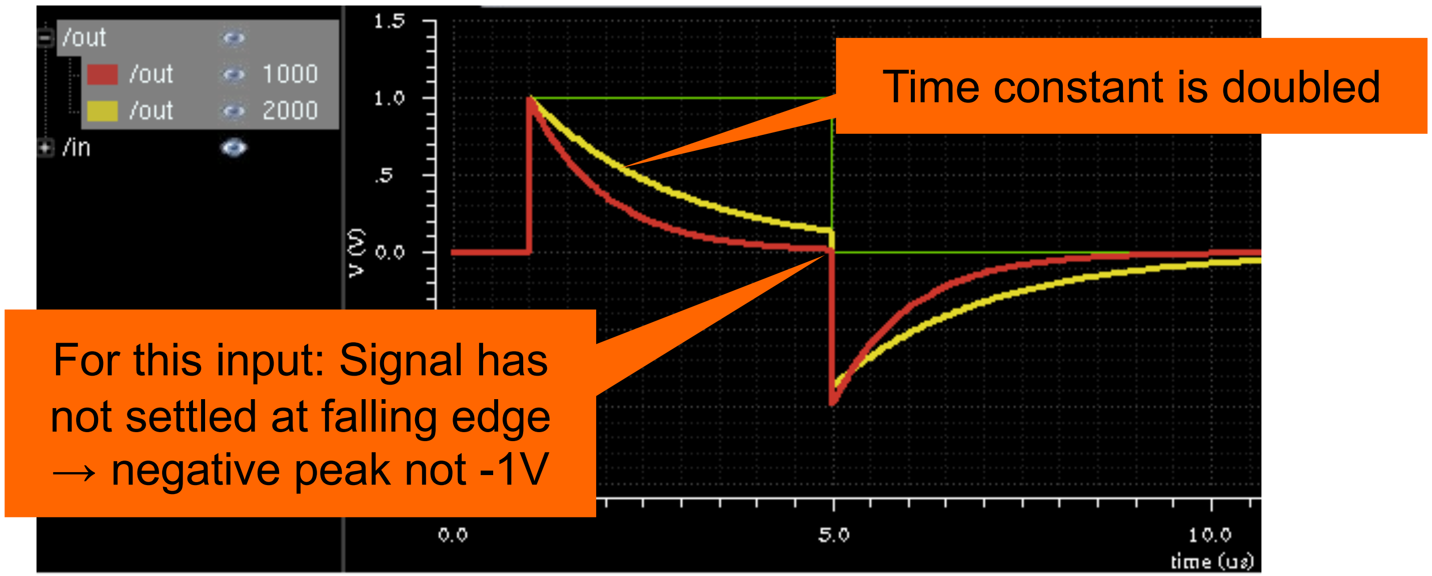


Solution 2: High Pass & Rect

- Double the resistor with a parametric sweep:



- Result:



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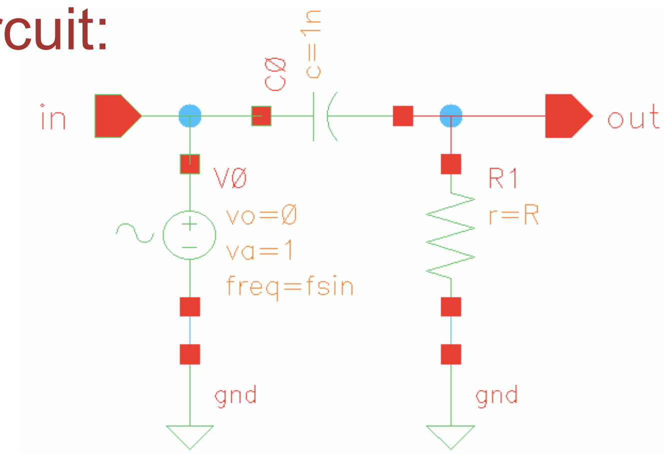
Exercise 3: High Pass & Sine Input

- Replace the rectangular generator by a sine wave generator (‘vsin’)
  - Set the *delay time* and *offset* to 0, the *amplitude* to 1V
  - What is the output of the high-pass circuit for a sine frequency ~10 x lower or ~10x higher than the corner frequency?
  - What is the output amplitude *exactly* at the corner frequency?
  - What is the phase shift between input and output at the corner frequency?
  - Try to run a parametric analysis, changing the value of the capacitor (or the resistor)

Solution 3: High Pass & Sine Input

- Circuit:

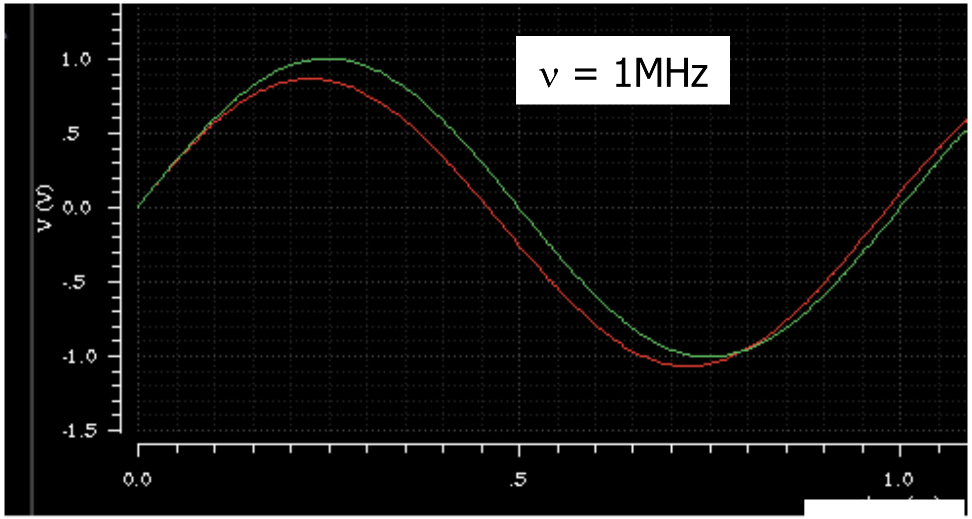


for R=1k, C=1n:

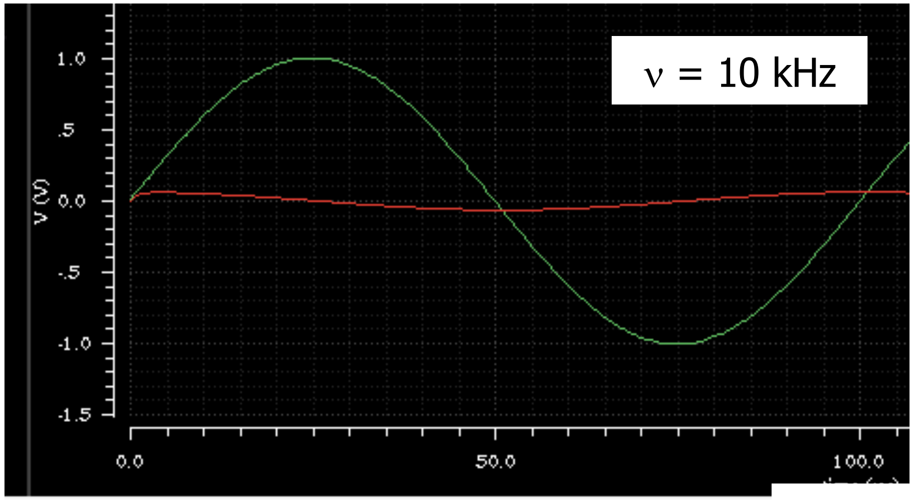
$RC = 1\mu s$

$\omega = 1$ MHz

$\nu = 1/(2\pi)$ MHz = 159 kHz



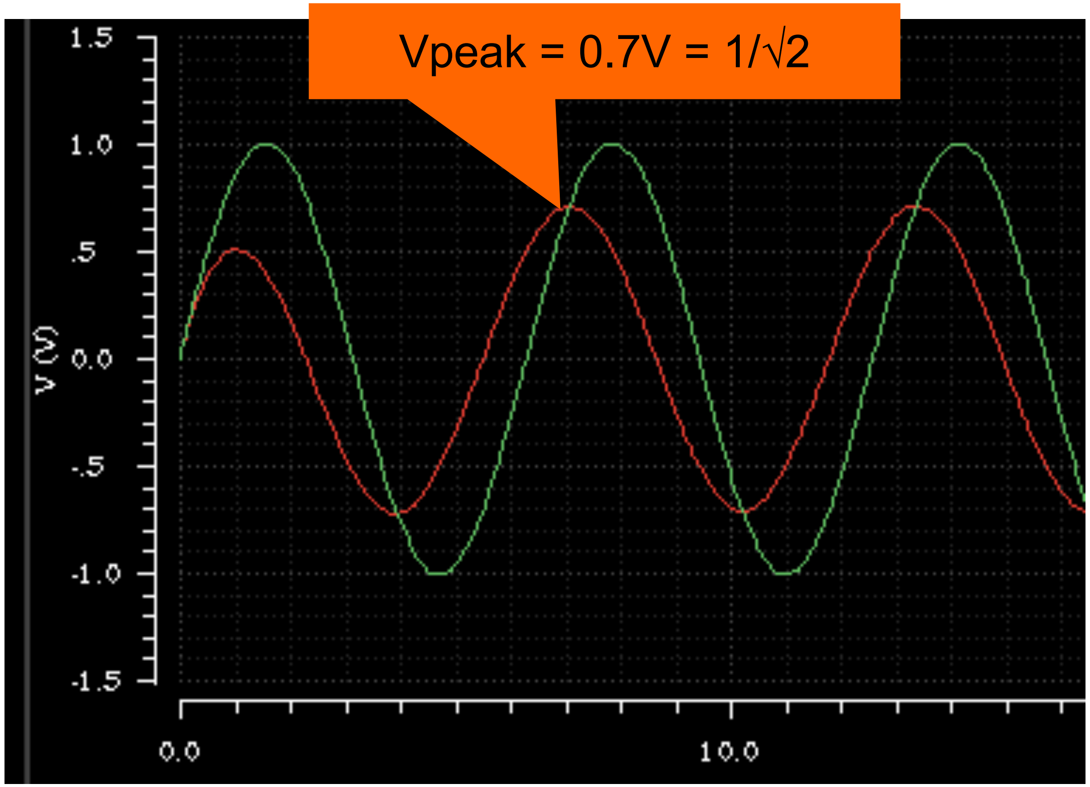
1µs

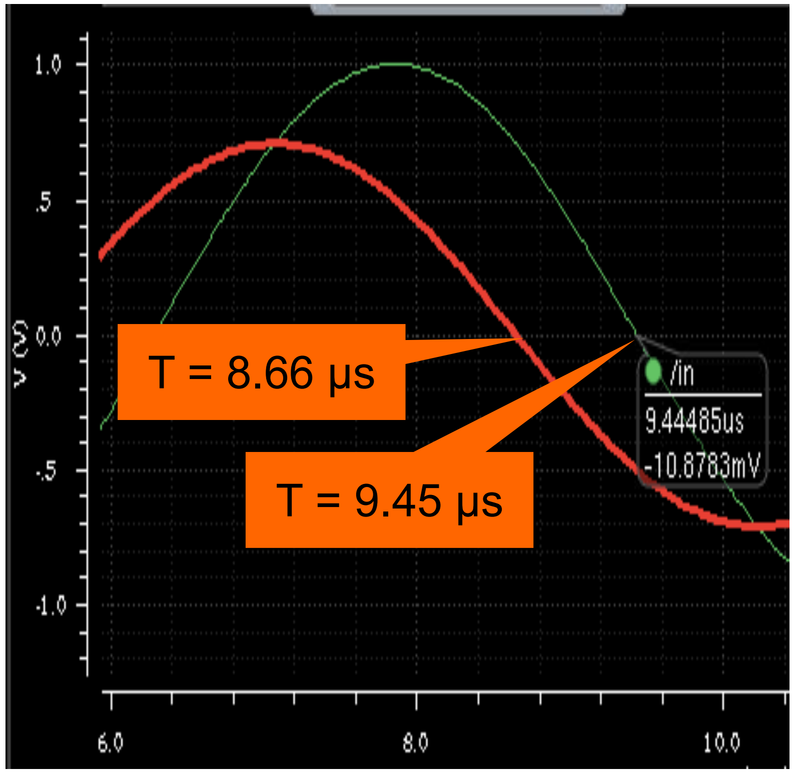


100 µs

Solution 3: High Pass & Sine Input

- At ν = 159 kHz (period = 2π µs = 6.28 µs)

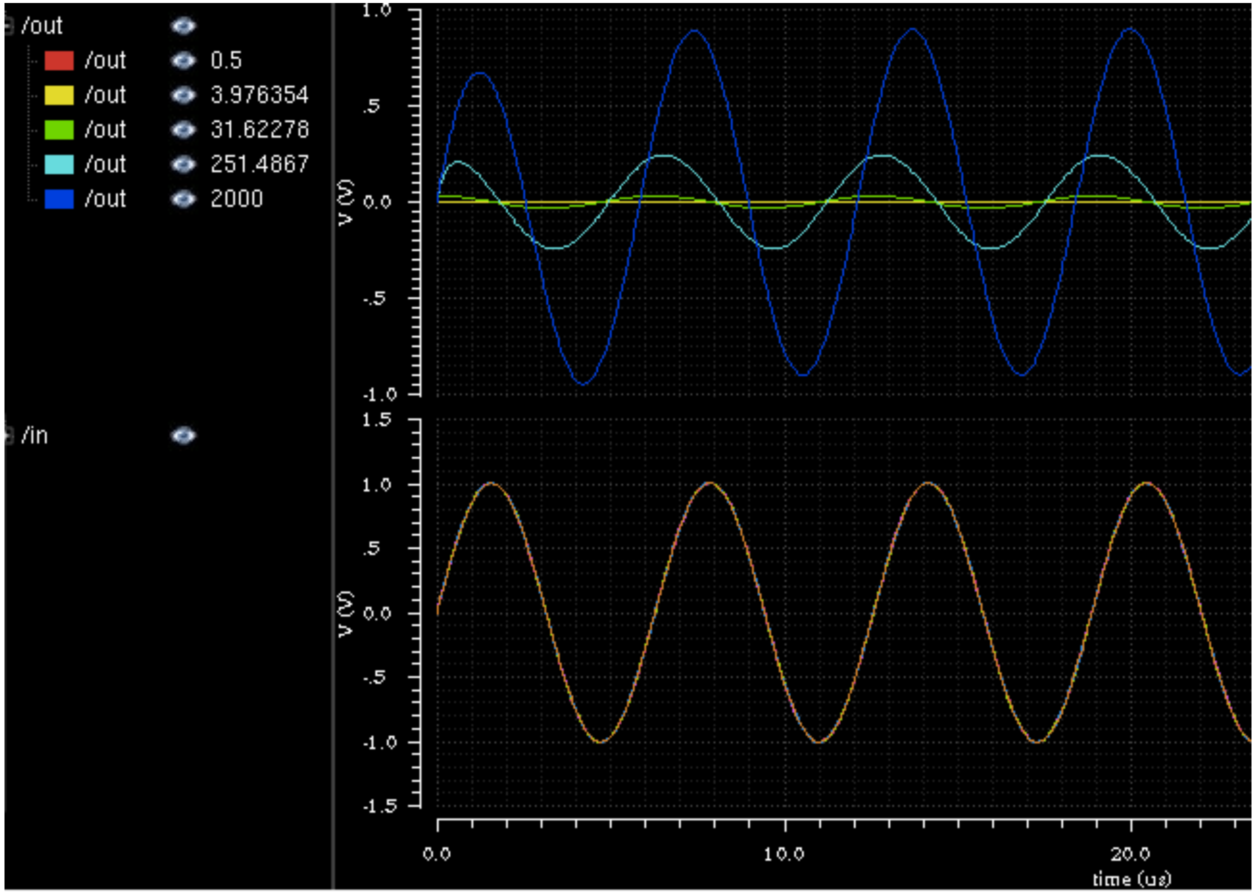




- Phase shift: 9.45 µs – 8.66 µs = 0.79 µs ~ 1/8 period

Solution 3: High Pass & Sine Input

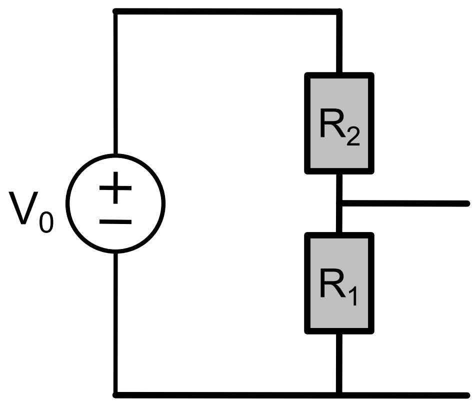
- Parametric Analysis (R=0.1 / 1 / 10k)



- Observation: Amplitude / Phase hard to see…
  → Better use AC sweep

Exercise 4:

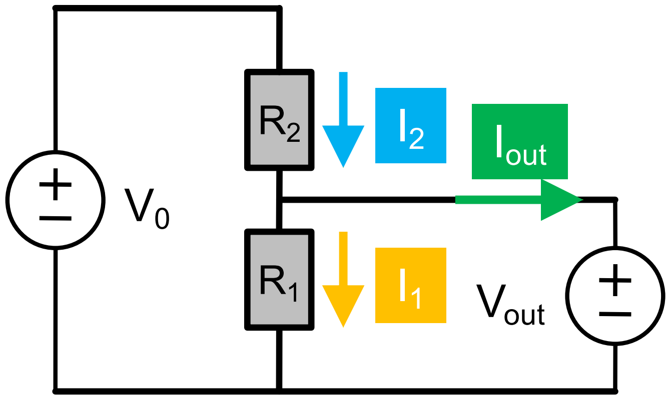
- Calculate the Thénevin Equivalent of a voltage source followed by a **general** resistive divider (again)

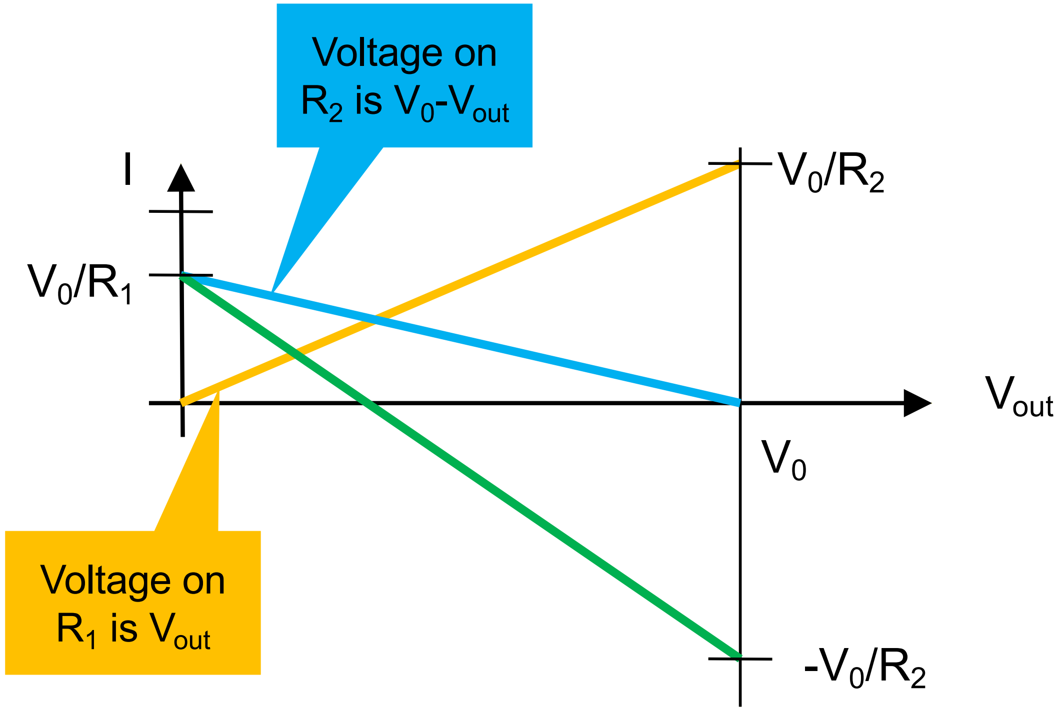


- *Simulate* this circuit for some values of R_1 and R_2
  - Connect a voltage source (or a current source) to the **output** and change its value with a dc sweep
    - Use an 'idc' current source and a 'vdc' voltage source
    - In dc sweep, select 'sweep component value' add chose 'dc'
    - OR: Use a design variable for the dc part of the source and sweep the design variable.
- Now *simulate* the equivalent circuit!
  - Best simulate both in parallel to compare

Solution 4

- For given output voltage, Currents in R_1 an R_2 are defined
- They just add





Solution 4

- To find V_0, consider $I_{out} = 0$ (no connection)
  $\rightarrow V_{out} = V_0 = I_0 R_1$
- To find R_V, make a short $\rightarrow I_{out} = I_0$
  $\rightarrow I_{short} = V_0 / R_V = I_0$
  $\rightarrow R_V = V_0 / I_0 = R_1$