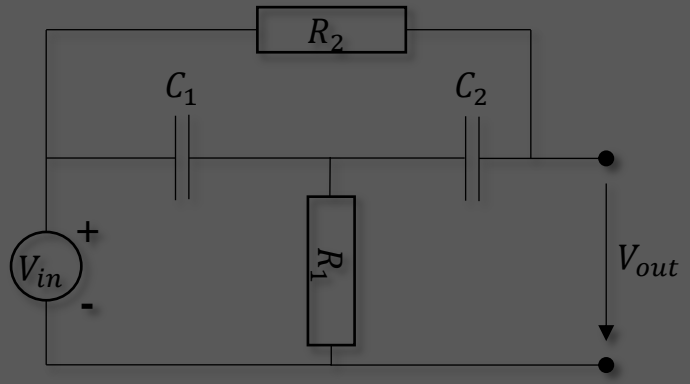
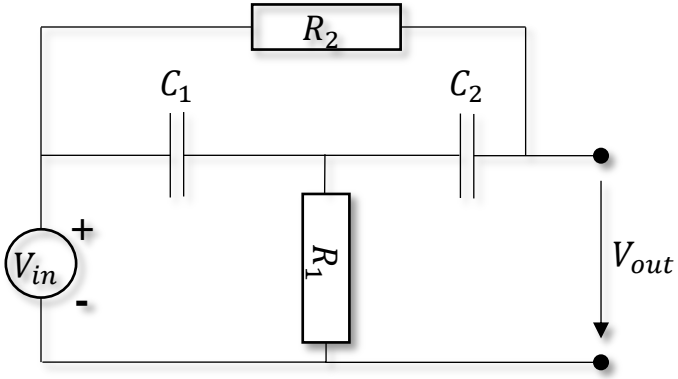
Modeling & Simulation of a Notch Filter using solidThinking *Activate*



Notch Filter

A notch filter circuit is used to remove an unwanted frequency or range of frequencies from a signal.

Our notch frequency is designed at $\approx 100 \frac{rad}{s}$.



Targets

- Learn how to…
  - … build a block diagram model a second order circuit
  - … plot a frequency sweep response of the circuit

Creation and Simulation of a Notch Filter

Theoretical background and how to implement it using *Activate*

Step 1: Construction of equations

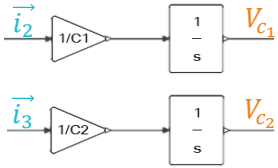
Step 2: Implementation using *Activate*

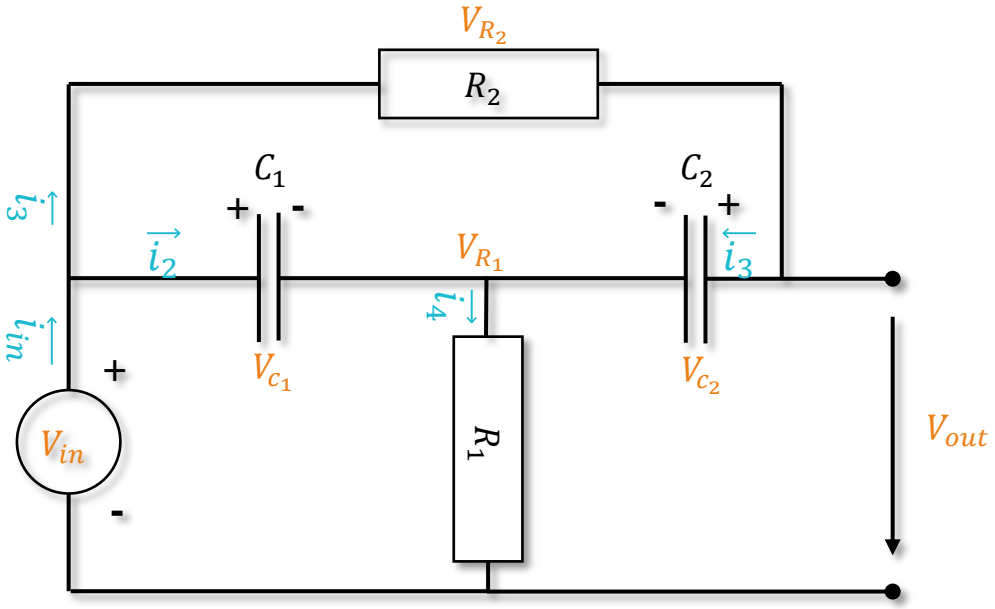
Step 3: Validation of the results

Step 1: Construction of equations

- *Kirchhoff's* nodal rule:
  - At any node: $\sum_{s=1}^{m} i_s = 0$

- Integral Causality Equations:
  - *Objective: Avoid differentiating to improve numerical stability*
  - $V_{C_j} = \frac{1}{C_j}\int_0^t i_j dt$

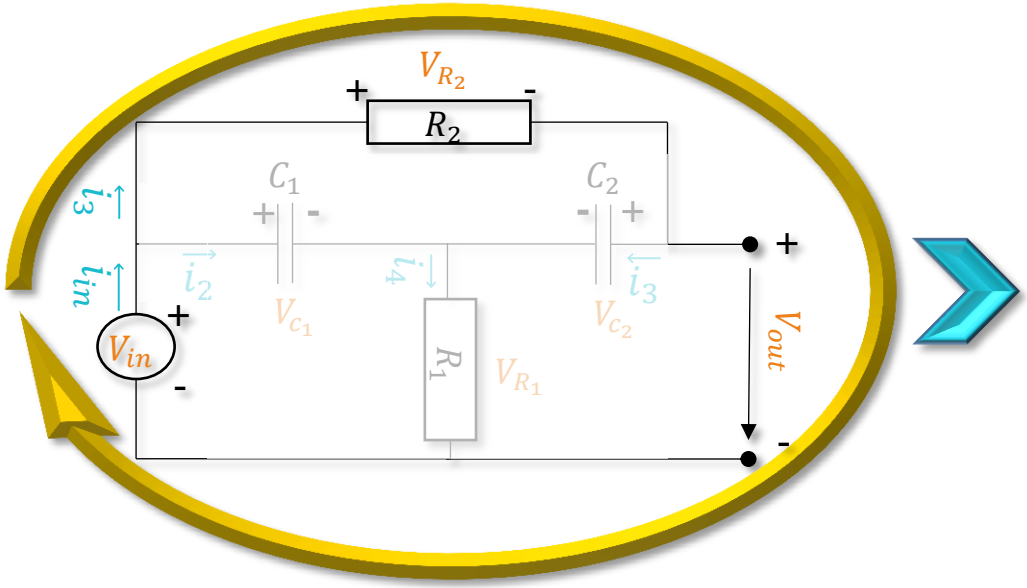


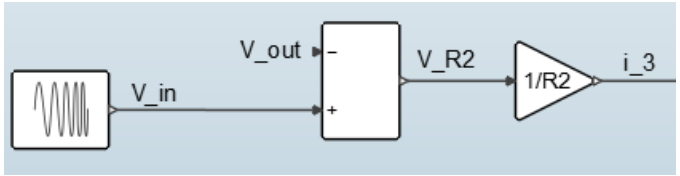


- *Kirchhoff's* mesh rule:
  - In a closed loop: $\sum_{k=1}^{n} V_k = 0$

Step 2: Implementation using *Activate*

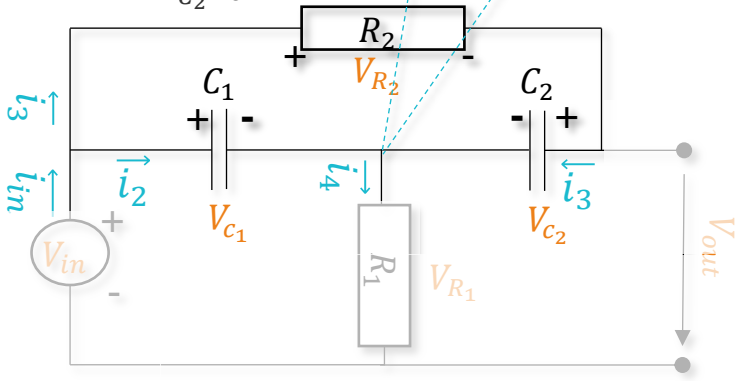
- *Kirchhoff's* mesh rule: $-\mathrm{V_{in}} + V_{R_2} + V_{\mathrm{out}} = 0$

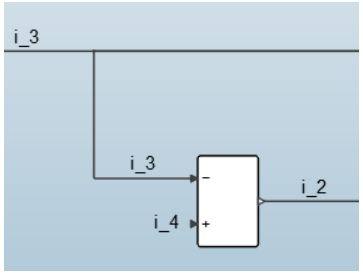


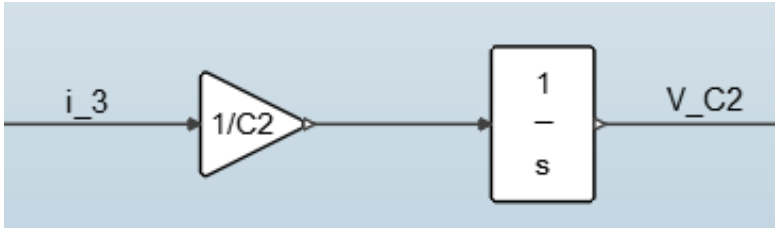


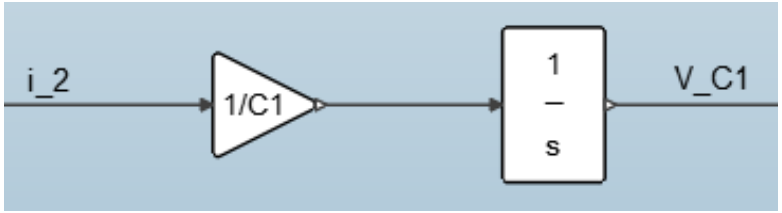
Step 2: Implementation using *Activate*

- Kirchhoffs nodal rule: $i_2 + i_3 = i_4$
- Integral Causality Equations:
  - $V_{C_1} = \frac{1}{C_1}\int_0^t i_2 dt$
  - $V_{C_2} = \frac{1}{C_2}\int_0^t i_3 dt$



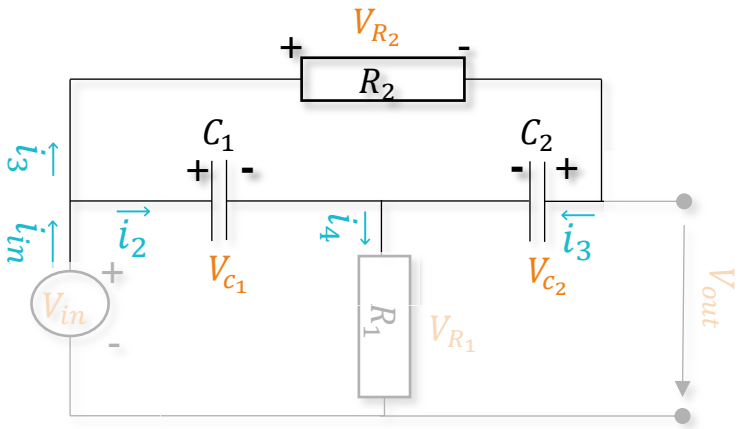


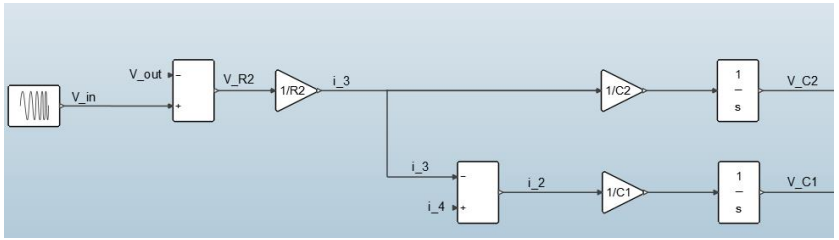




Step 2: Implementation using *Activate*

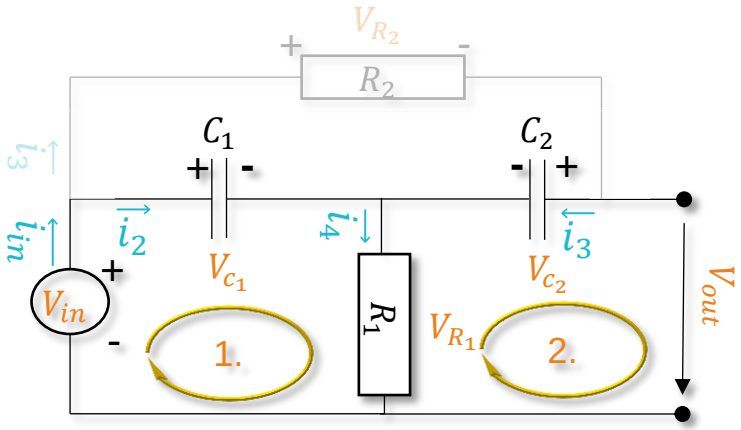
- Model so far:
  - The current i_4 and voltage V_{out} are still unknown.

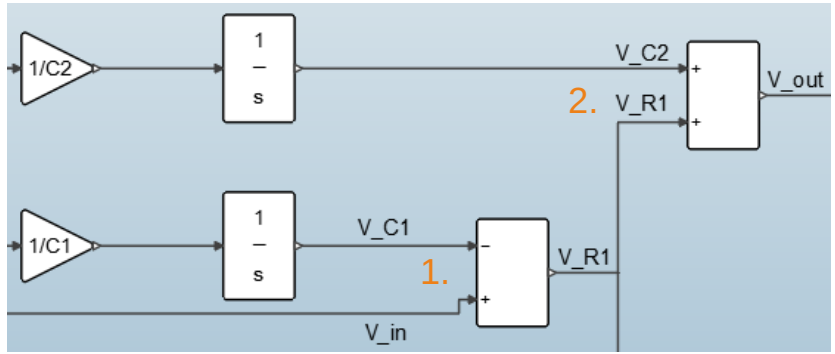




Step 2: Implementation using *Activate*

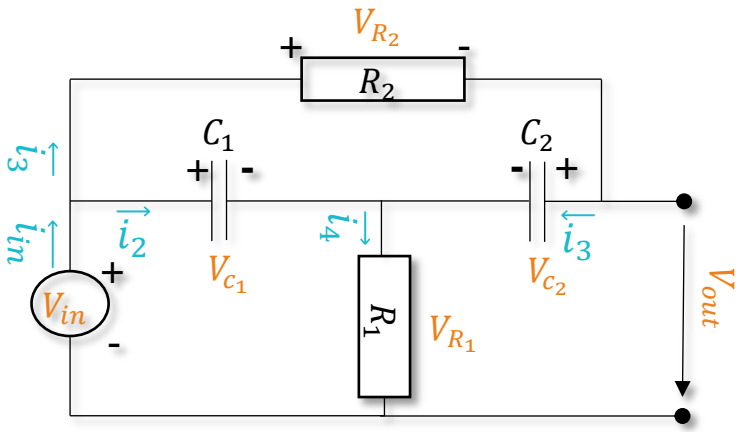
- *Kirchhoff's* mesh rule:
  - 1. $-\mathrm{V_{in}} + V_{C_1} + V_{\mathrm{R}_1} = 0 \Leftrightarrow V_{R_1} = V_{in} - V_{C_1}$
  - 2. $\mathrm{V_{R_1}} + \mathrm{V_{C_2}} - \mathrm{V_{out}} = 0 \Leftrightarrow V_{out} = V_{C_2} + V_{R_1}$

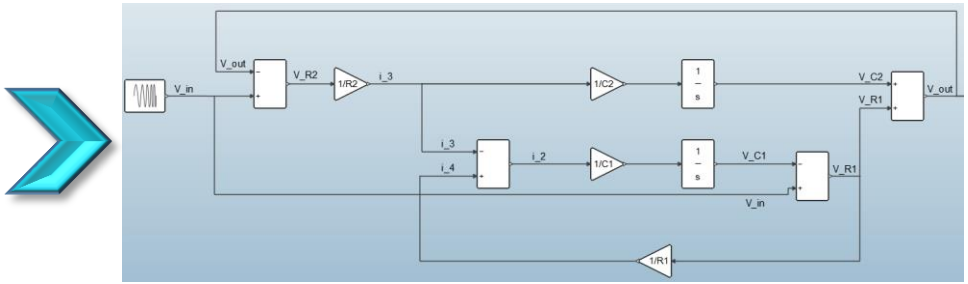




Step 2: Implementation using *Activate*

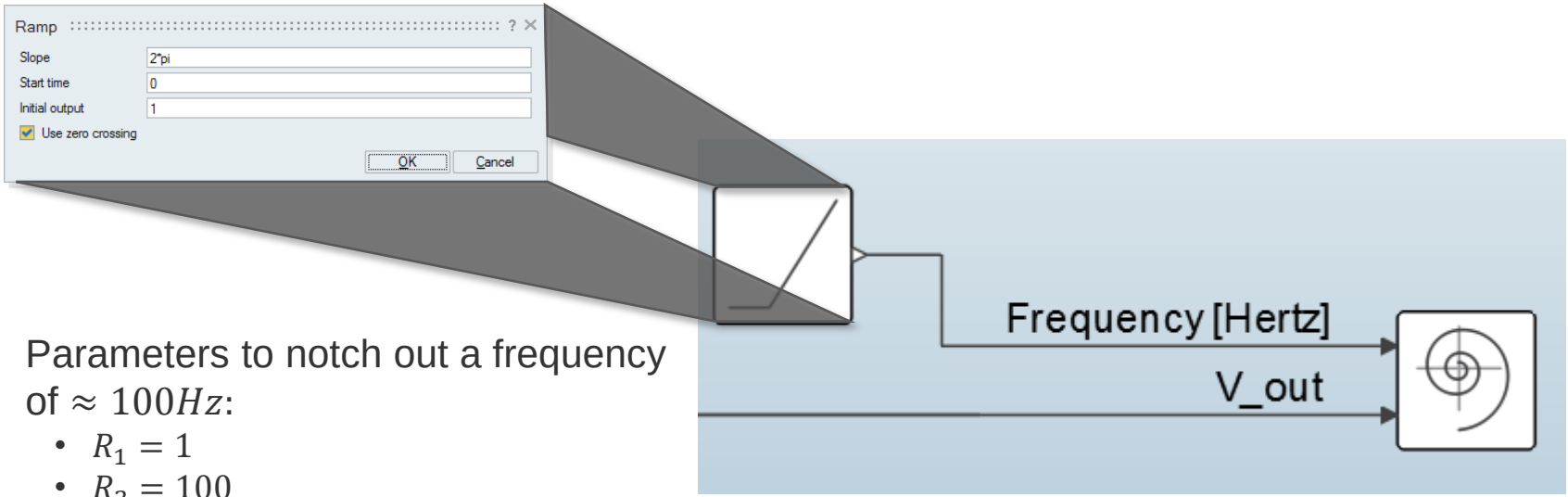
- Complete model:
- Feed back V_{out} and i_4.
  - $i_4 = \frac{1}{R_1} V_{R_1}$





Step 2: Implementation using *Activate*

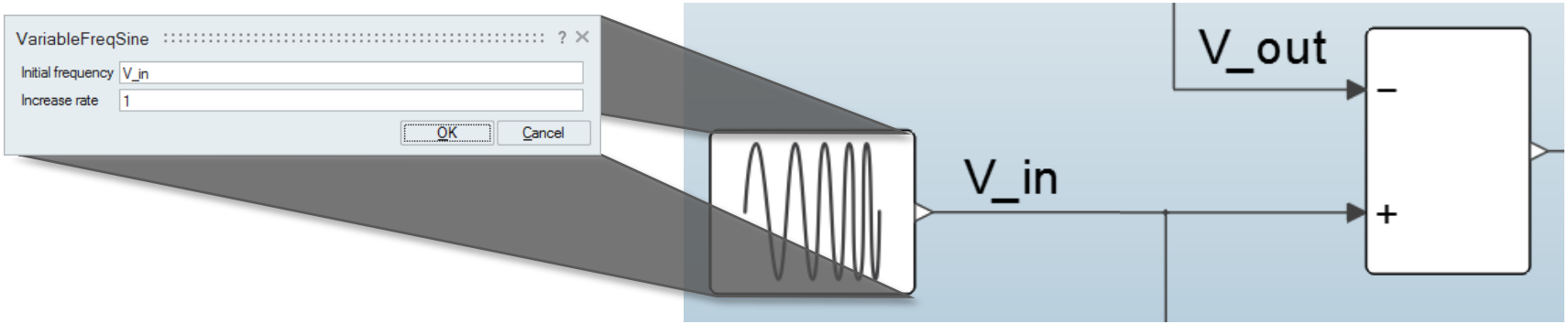
- Plotting the frequency vs. the output voltage V_{out} as a sweep frequency response.



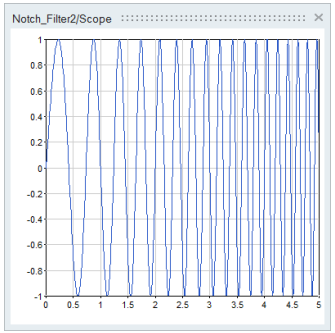
- Parameters to notch out a frequency of $\approx 100Hz$:
  - $R_1 = 1$
  - $R_2 = 100$
  - $C_1 = 0.001$
  - $C_2 = 0.001$
  - $V_{in} = 1$

Step 2: Implementation using *Activate*

- Plotting the frequency vs. the output voltage V_{out} as a sweep frequency response.

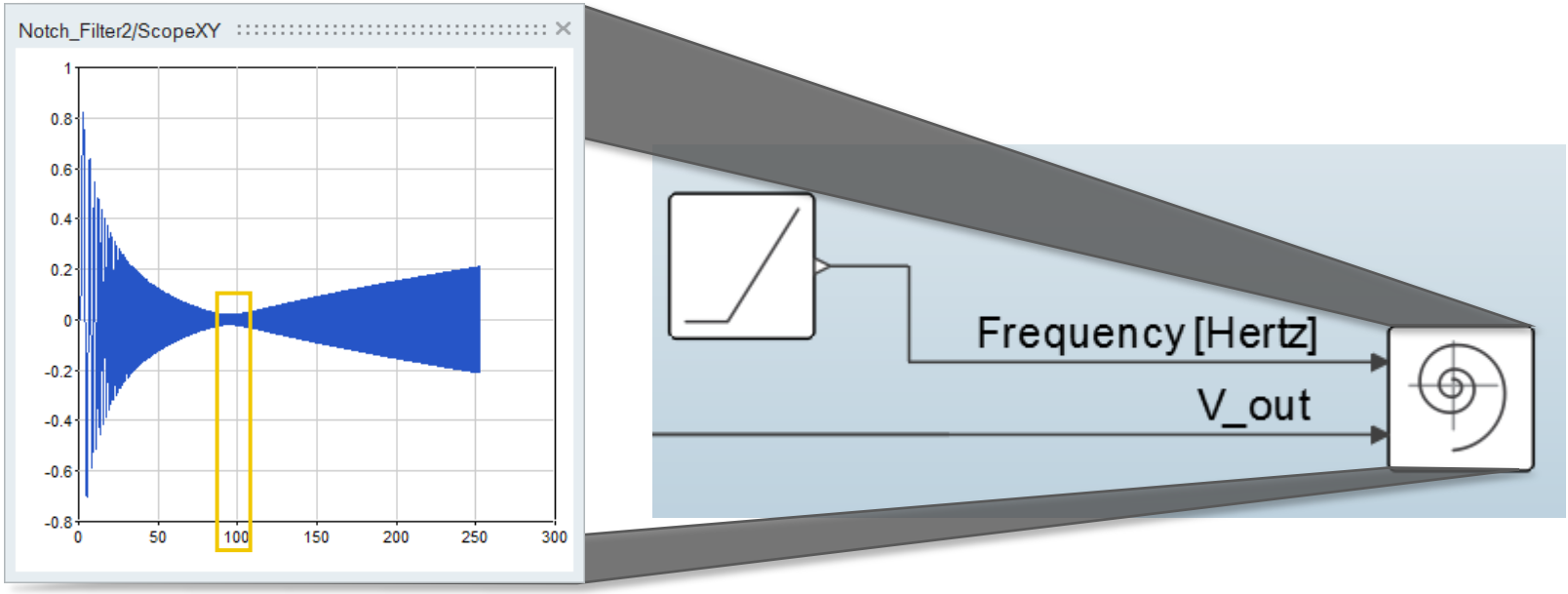


- This "*VariableFreqSine"* block plots a Sinewave starting with a frequency of 1 Hz and increases itself with 1 $\frac{rad}{s}$. →



Step 3: Validation of the results

- Plotting the frequency vs. the output voltage V_{out} as a sweep frequency response.



- The frequency near to $100\ Hz$ is notched out by this electrical circuit.