Lab 5 Review

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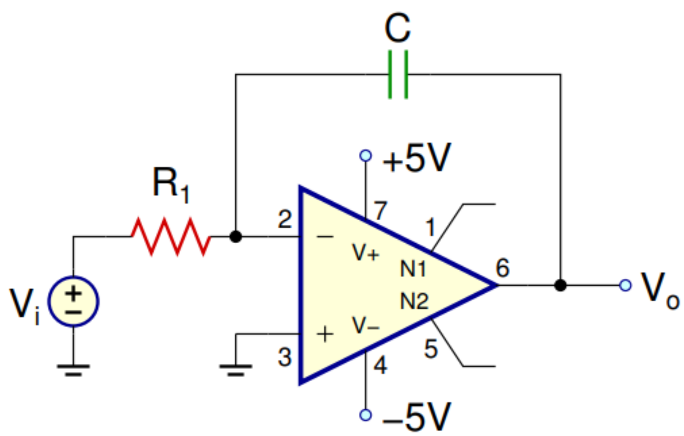
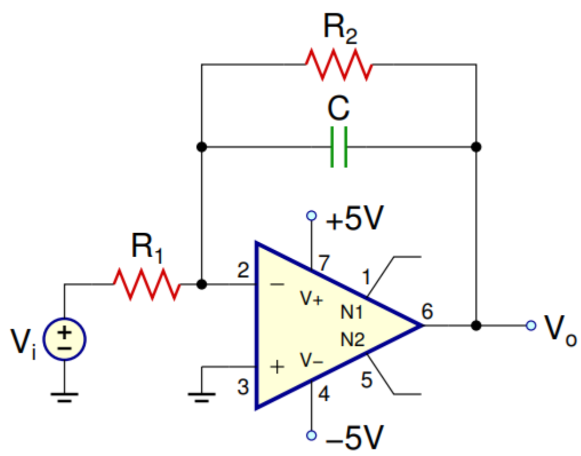
Ideal Integrator



$$\frac{V_o}{V_i}(s) = -\frac{Z_c}{R_1} = -\frac{1}{SR_1C}$$

- The DC (s=0) gain is theoretically infinite
- This design is not practical since any small DC signal (like the input offset) will saturate the output over time

Lossy Integrator



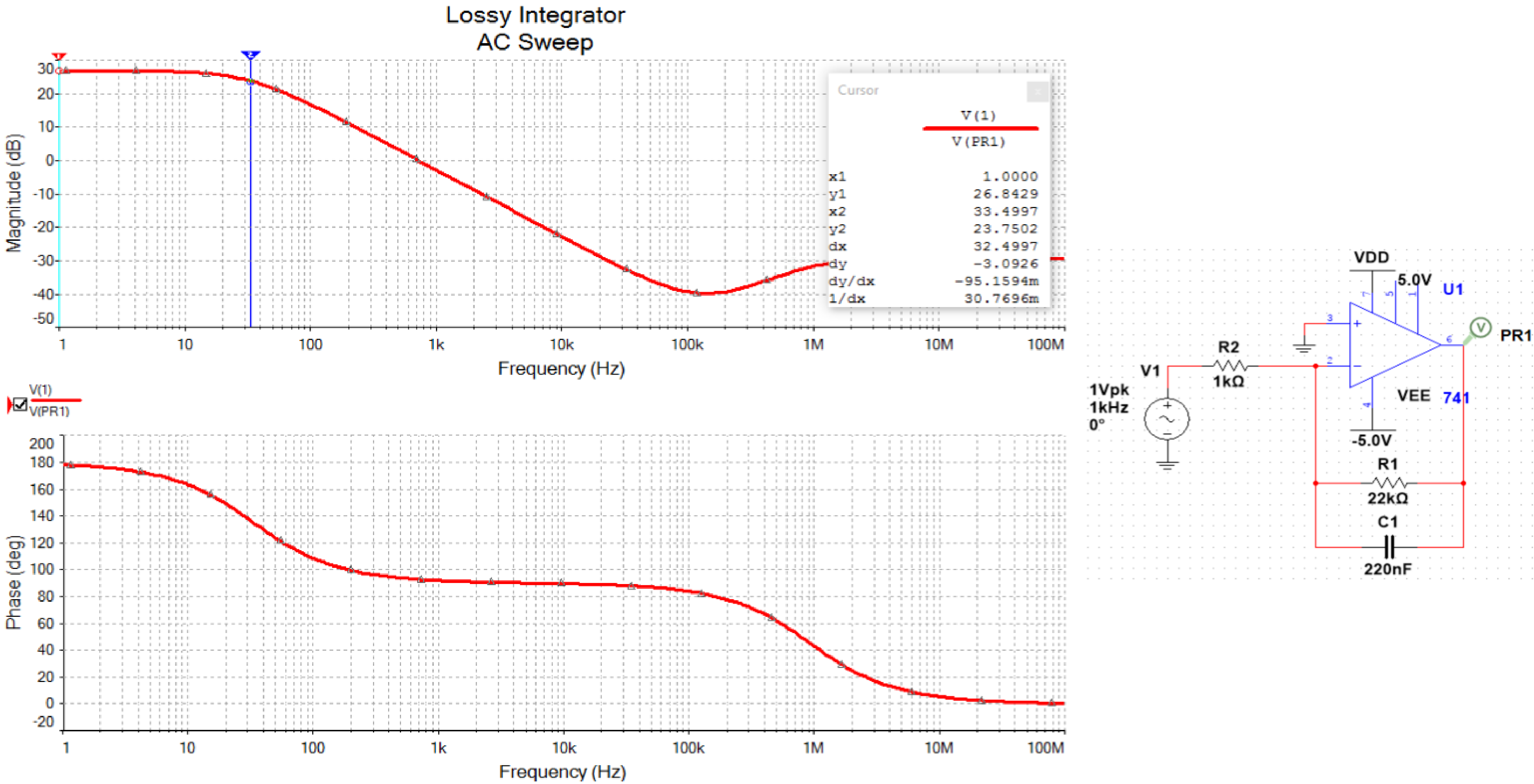
$$\frac{V_o}{V_i}(s) = -\frac{R_2||Z_c}{R_1}$$

$$\frac{V_o}{V_i}(s) = = -\frac{1}{R_1}\frac{\mathrm{R}_2}{1+SR_2C}$$

$$\frac{V_o}{V_i}(s) = -\frac{\frac{R_2}{R_1}}{1+SR_2C}$$

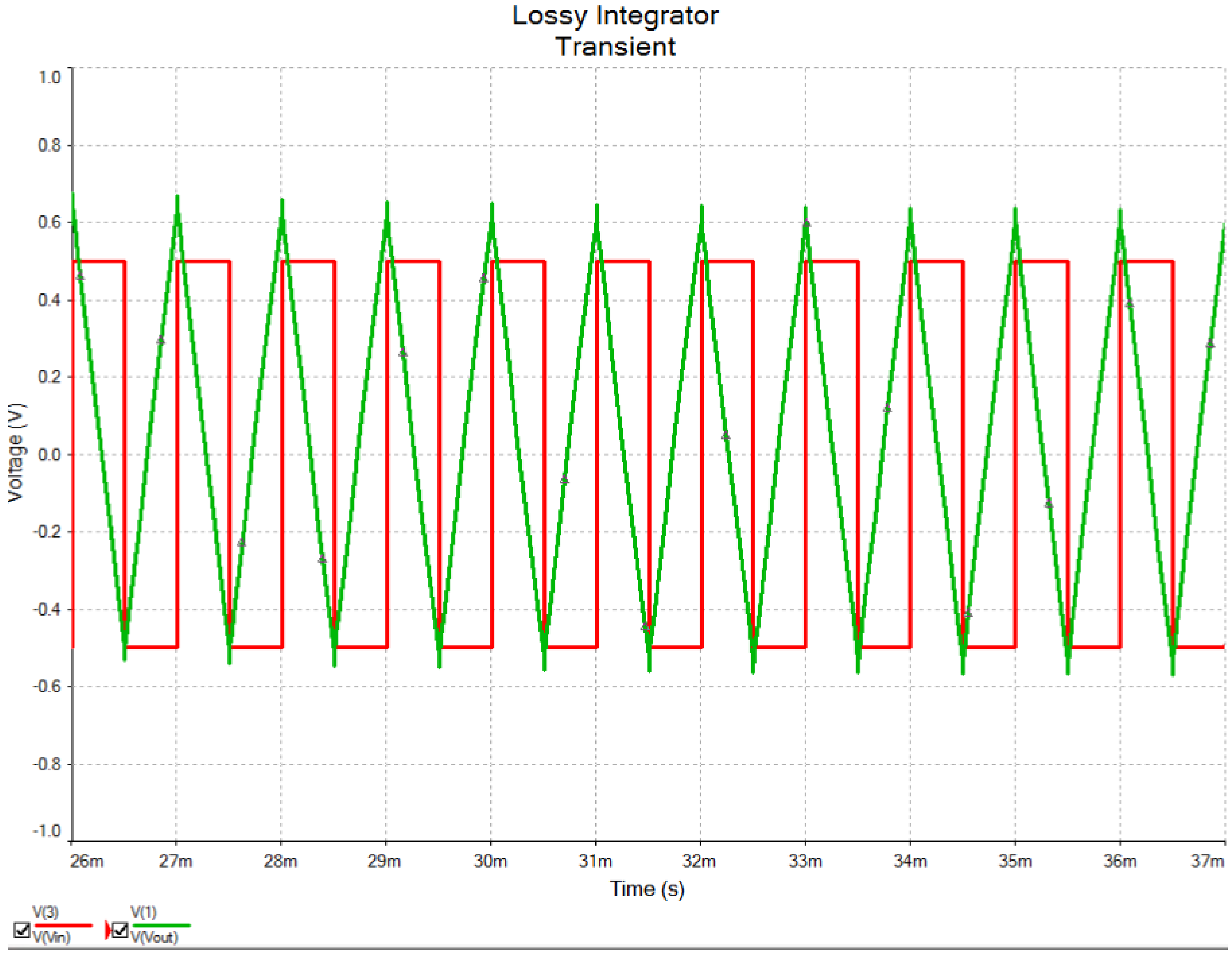
- The lossy integrator is a practical implementation
- Includes a large parallel resistor to C to have a controlled DC gain
- It is a first-order low pass filter with low cut-off frequency

Bode Plot



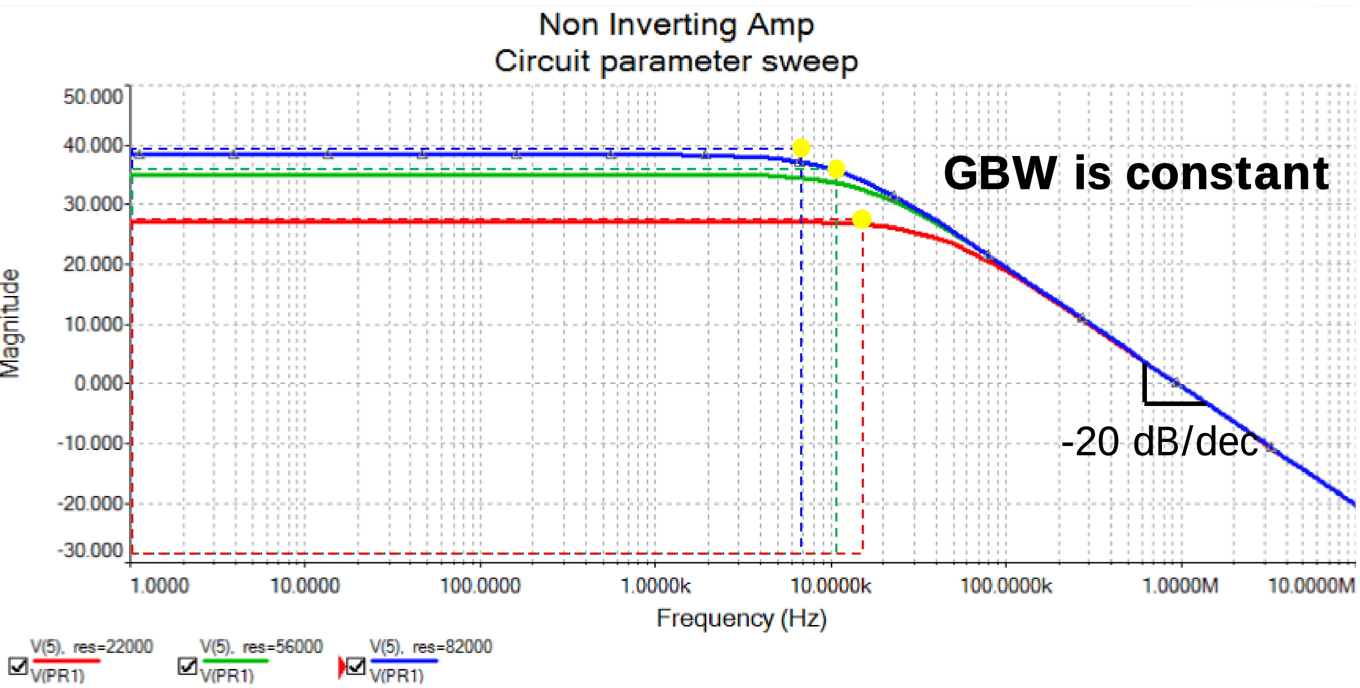
- First order LPF with f_{3dB} of 33 kHz and DC gain of -22 V/V or 26.84 dB

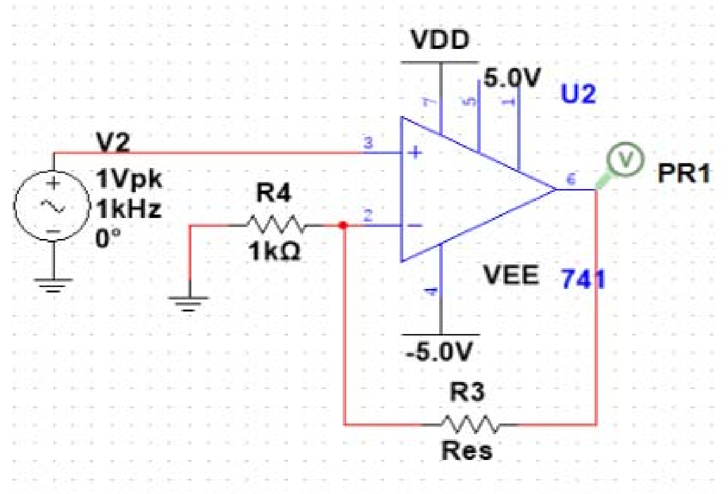
Transient



- What is the result of integrating a square wave?

Finite GBW Limitations

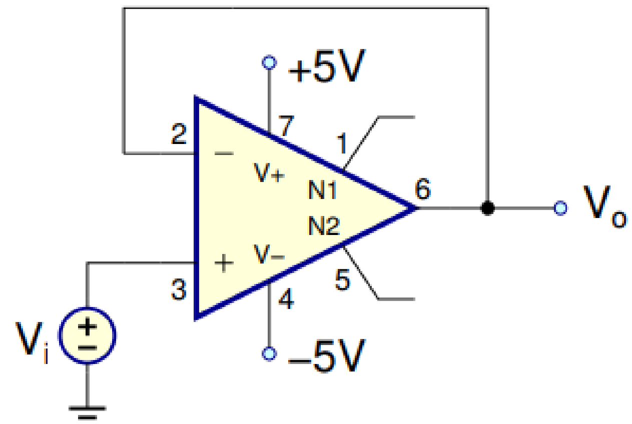




- The gain-bandwidth product is a finite constant
- There is a trade off between the gain and bandwidth of the closed-loop amplifier

Slew Rate Limitations

- The slew rate is the maximum rate of change at the output of the amplifier
- To avoid distortion:

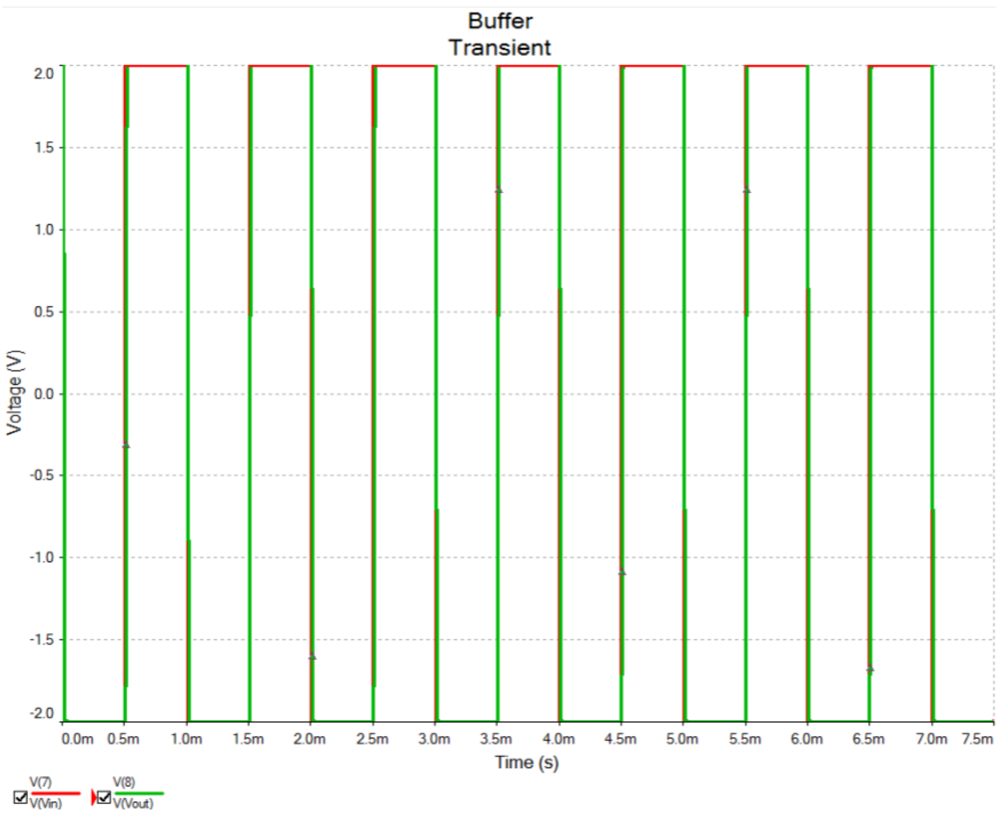


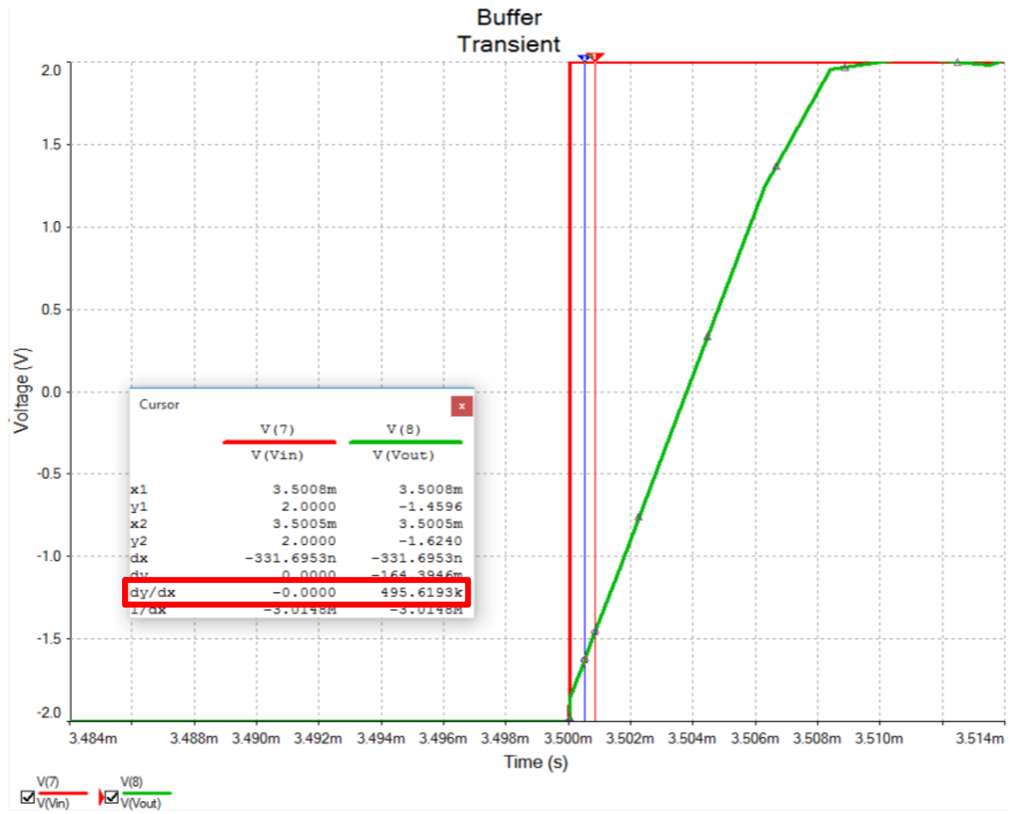
$$\left.\frac{\mathrm{d}V_{out}}{\mathrm{d}t}\right|_{max} \leq SR \quad [V/s]$$

- If the output is a sinusoidal signal with amplitude A

$$\left.\frac{\mathrm{d}V_{out}}{\mathrm{d}t}\right|_{max} = A2\pi f Cos(2\pi f t)|_{max} = A2\pi f \leq 0.5\,\frac{V}{\mu s}$$

Slew Rate Limitations





- The slew rate can be measured in the lab by feeding a large square signal to the circuit and measuring the slope at the rising edge