OP-AMPS AND SIGNAL CONDITIONING

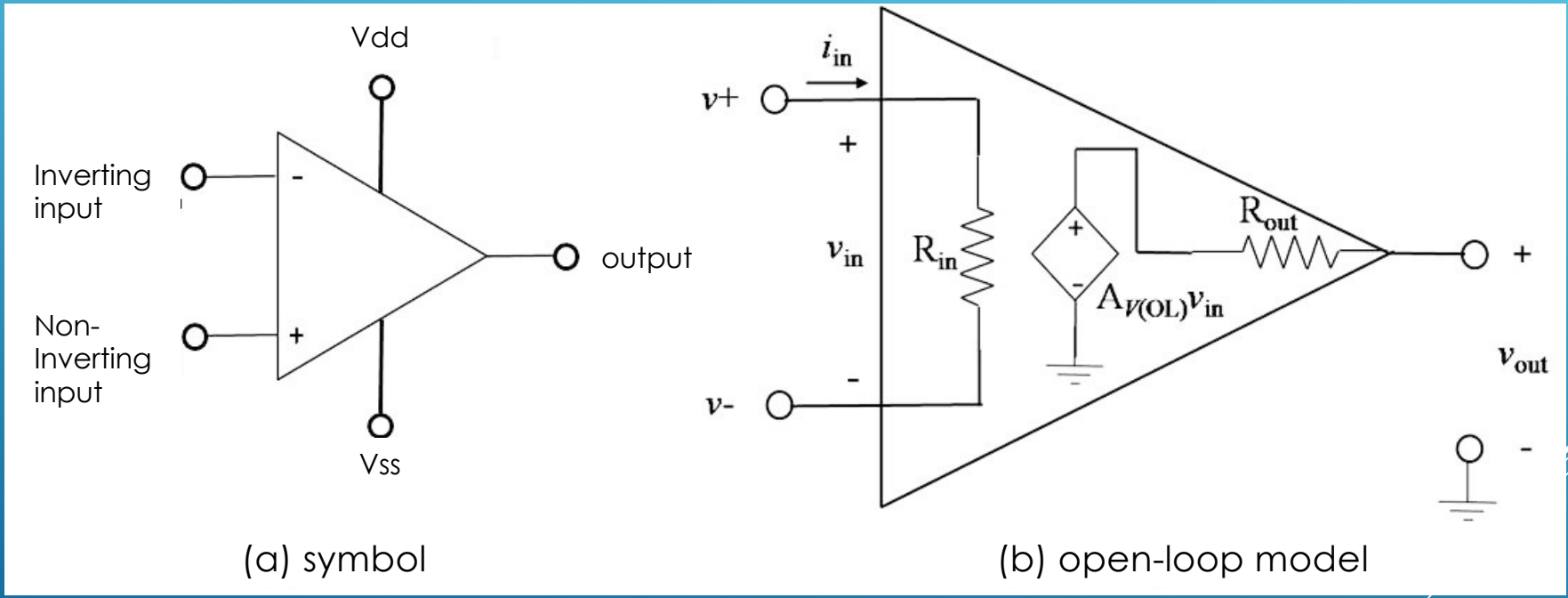
01205479 IoT for EE

Dr.Varodom Toochinda

TOPICS

- Symbols and Open-Loop model
- Desired Properties
- Inverting Amp
- Non-Inverting Amp
- Differential Amp
- Level shifter
- Active filters

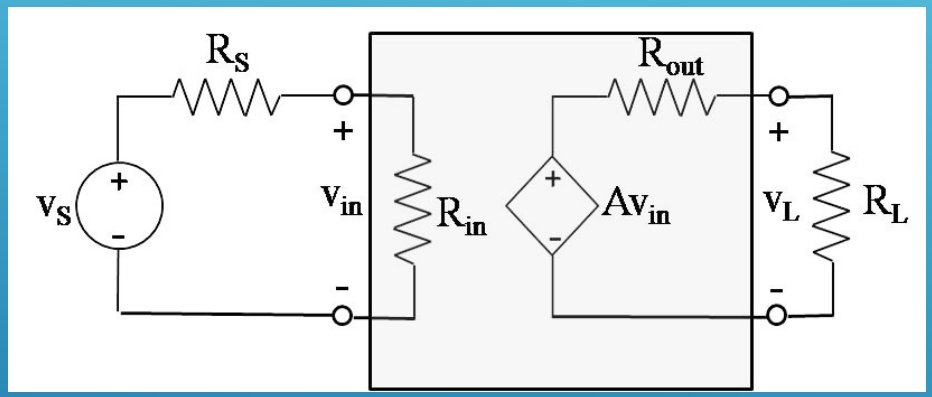
SYMBOLS AND OPEN-LOOP MODEL



(a) symbol

(b) open-loop model

DESIRED PROPERTIES OF IDEAL OP-AMP



$$v_L = A\left(\frac{R_{in}}{R_S + R_{in}}\frac{R_L}{R_{out} + R_L}\right)v_S$$

Ideal $$v_L(t) = Av_S(t)$$

Practical $$v_{in} = \frac{R_{in}}{R_S + R_{in}}v_S$$

$$v_L = Av_{in}\frac{R_L}{R_{out} + R_L}$$

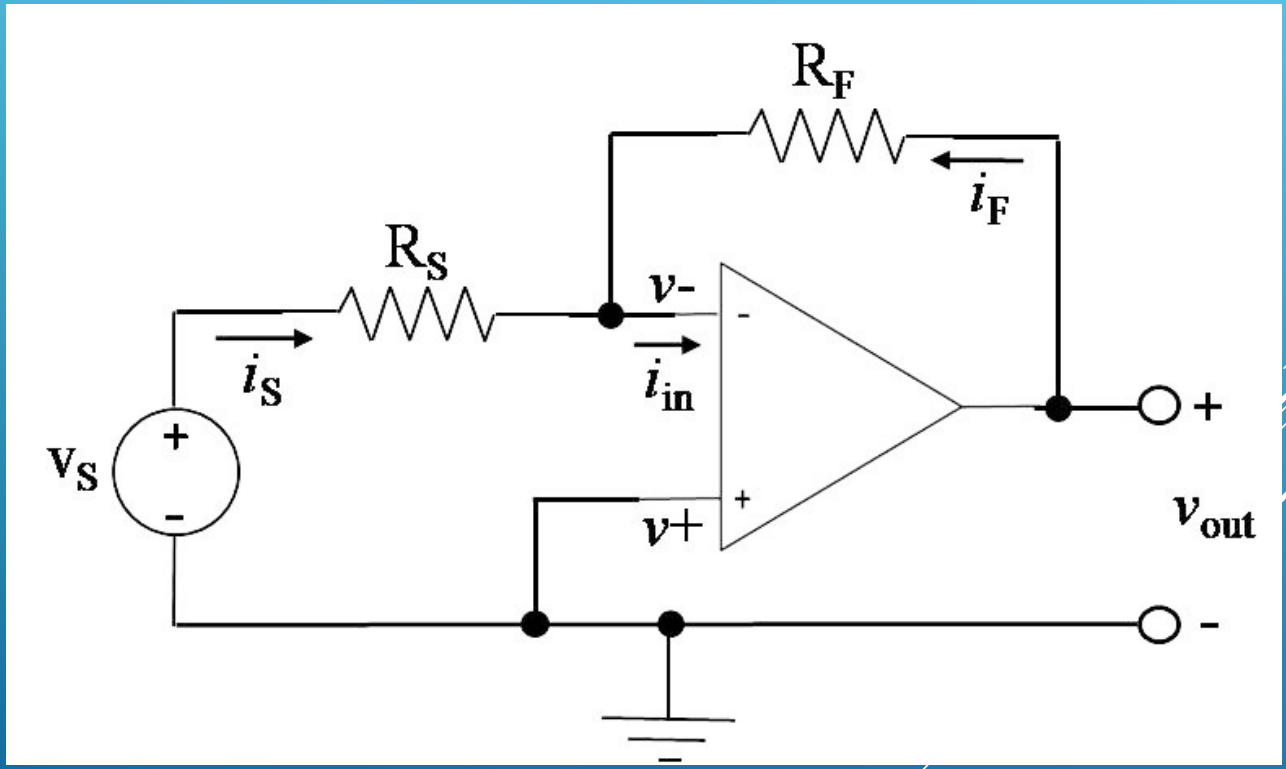
The value in parenthesis must approach 1, which is true when

$$R_{in} \to \infty$$

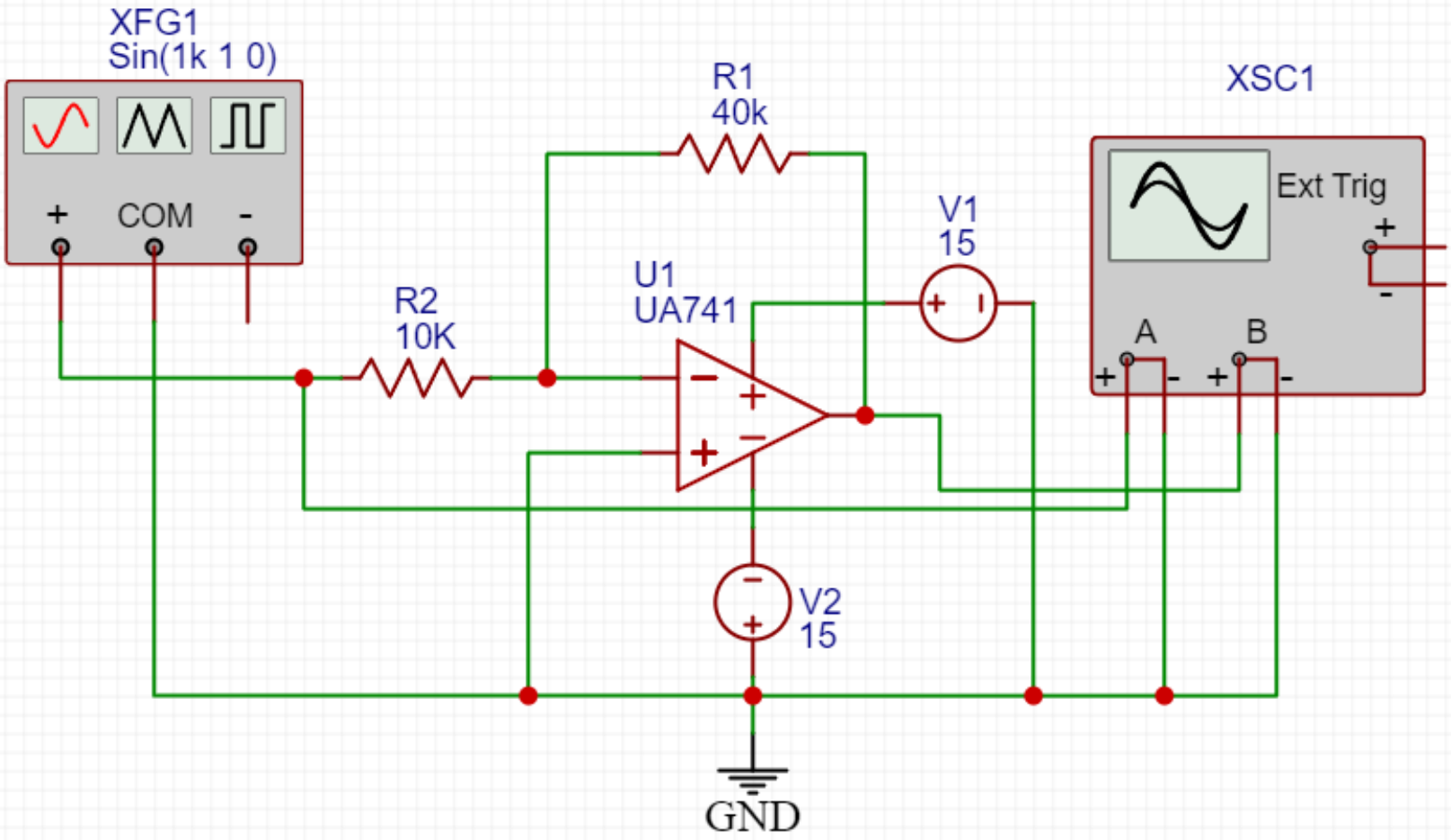
$$R_{out} \to 0$$

INVERTING AMPLIFIER

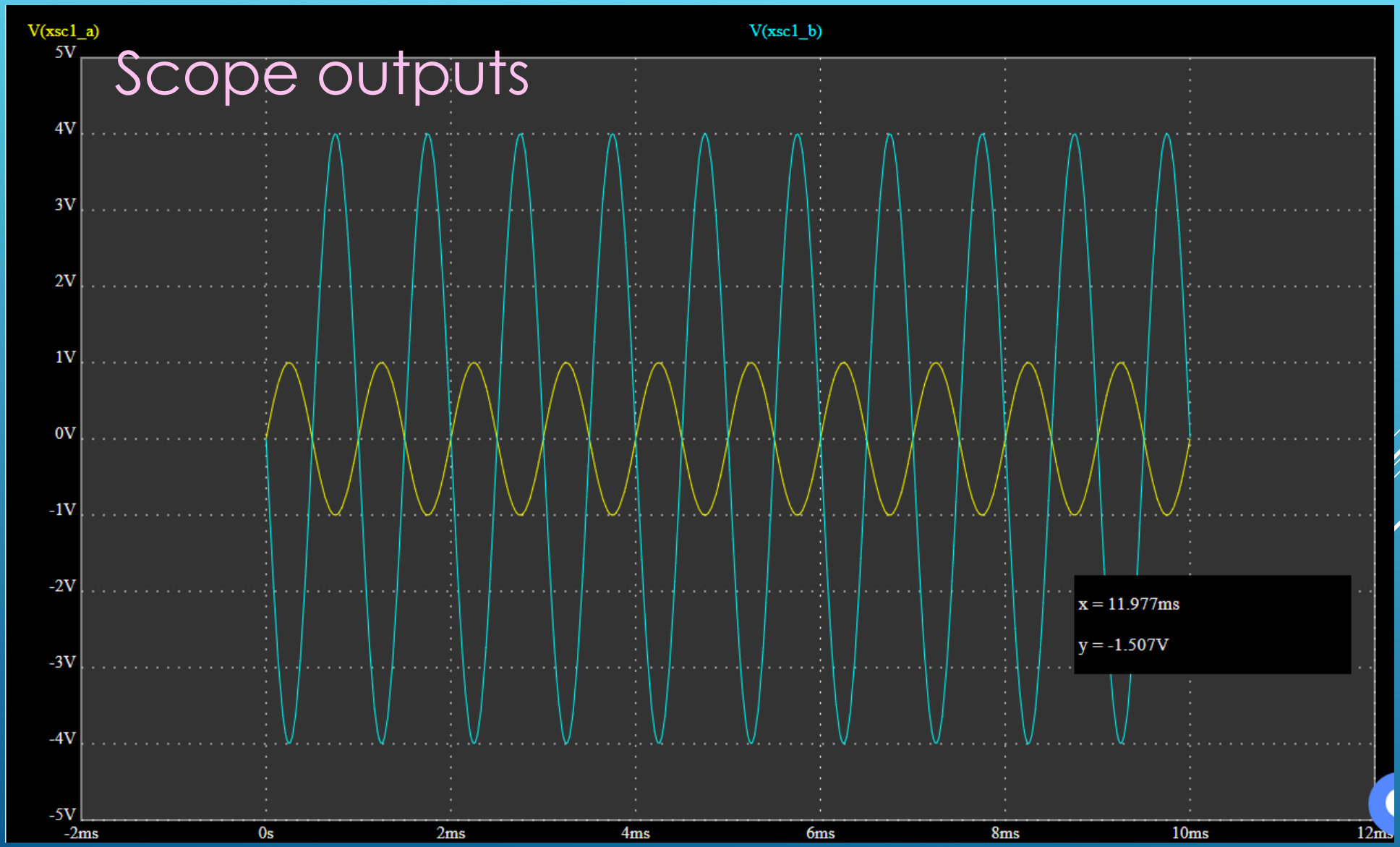
$$\frac{v_{out}}{v_S} = -\frac{R_F}{R_S}$$



Inverting amp simulation

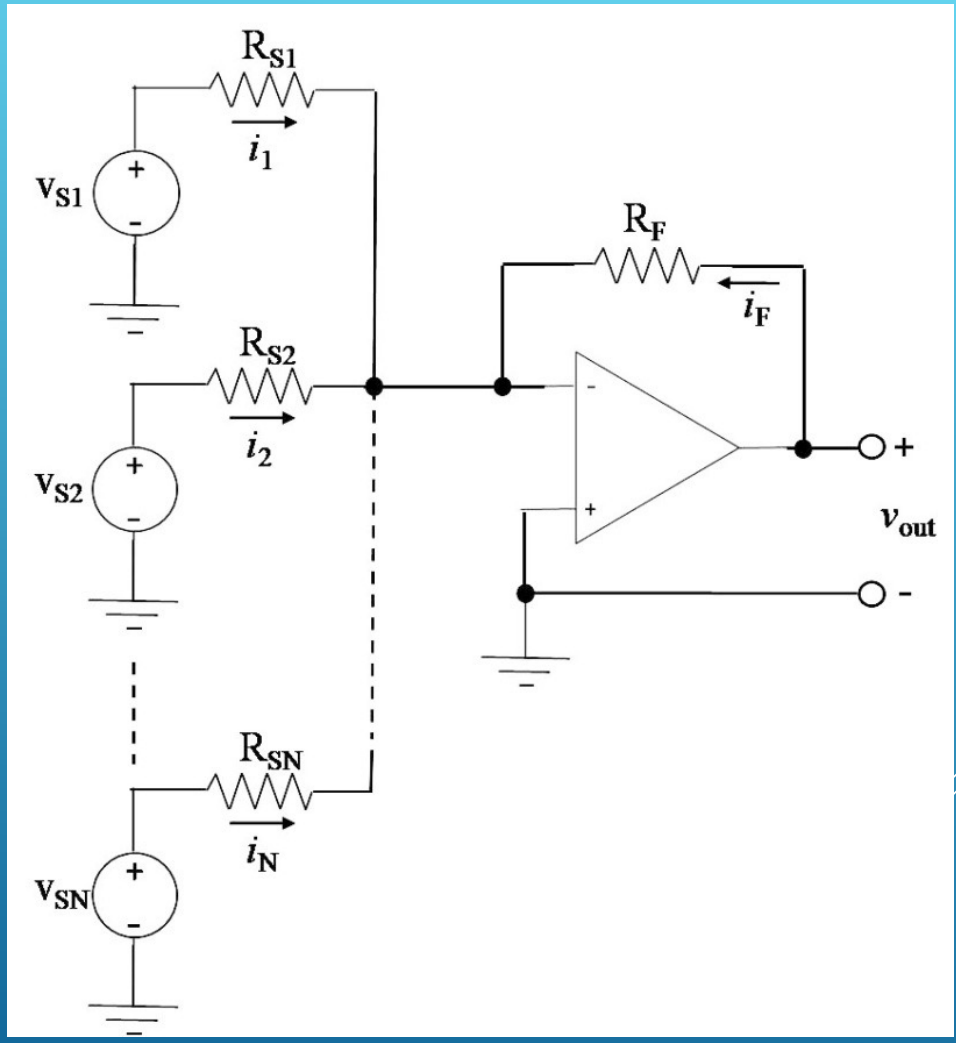


Scope outputs



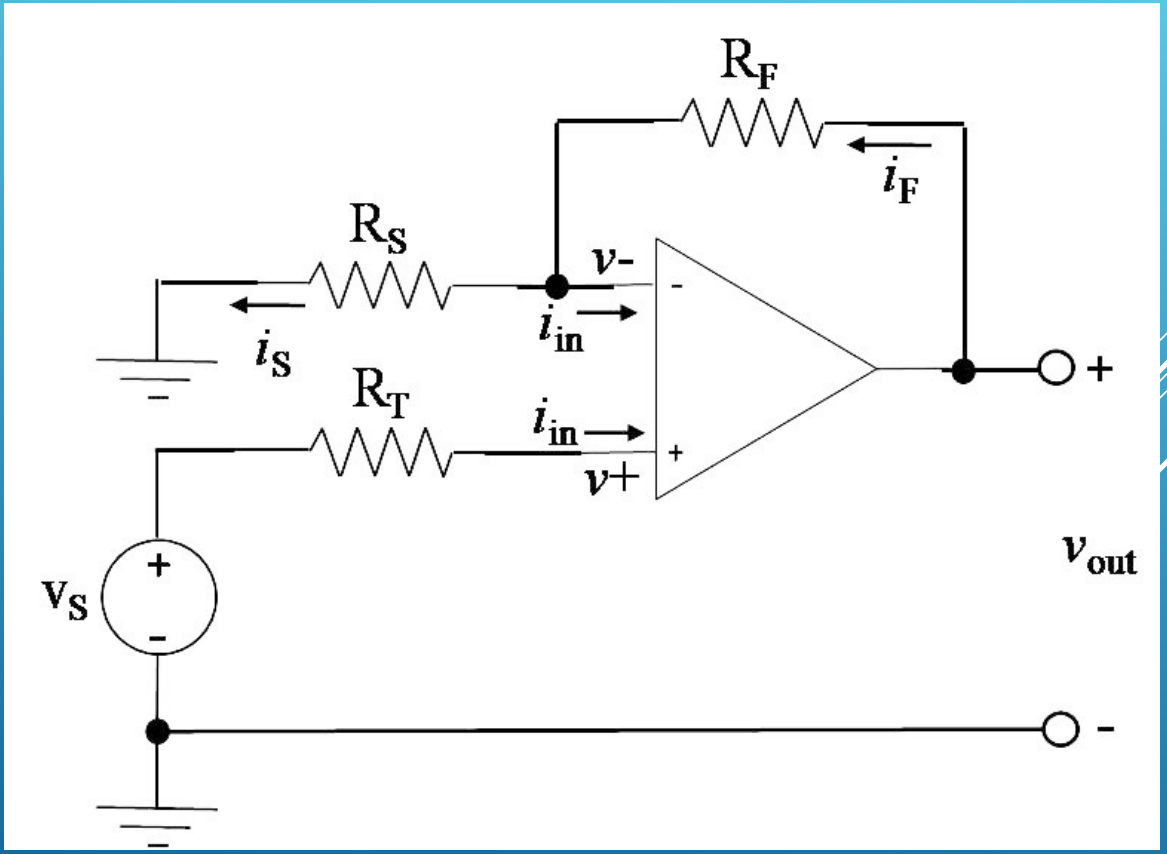
MIXER CIRCUIT

$$v_{out} = -\sum_{n=1}^{N} \frac{R_F}{R_{Sn}} v_{Sn}$$

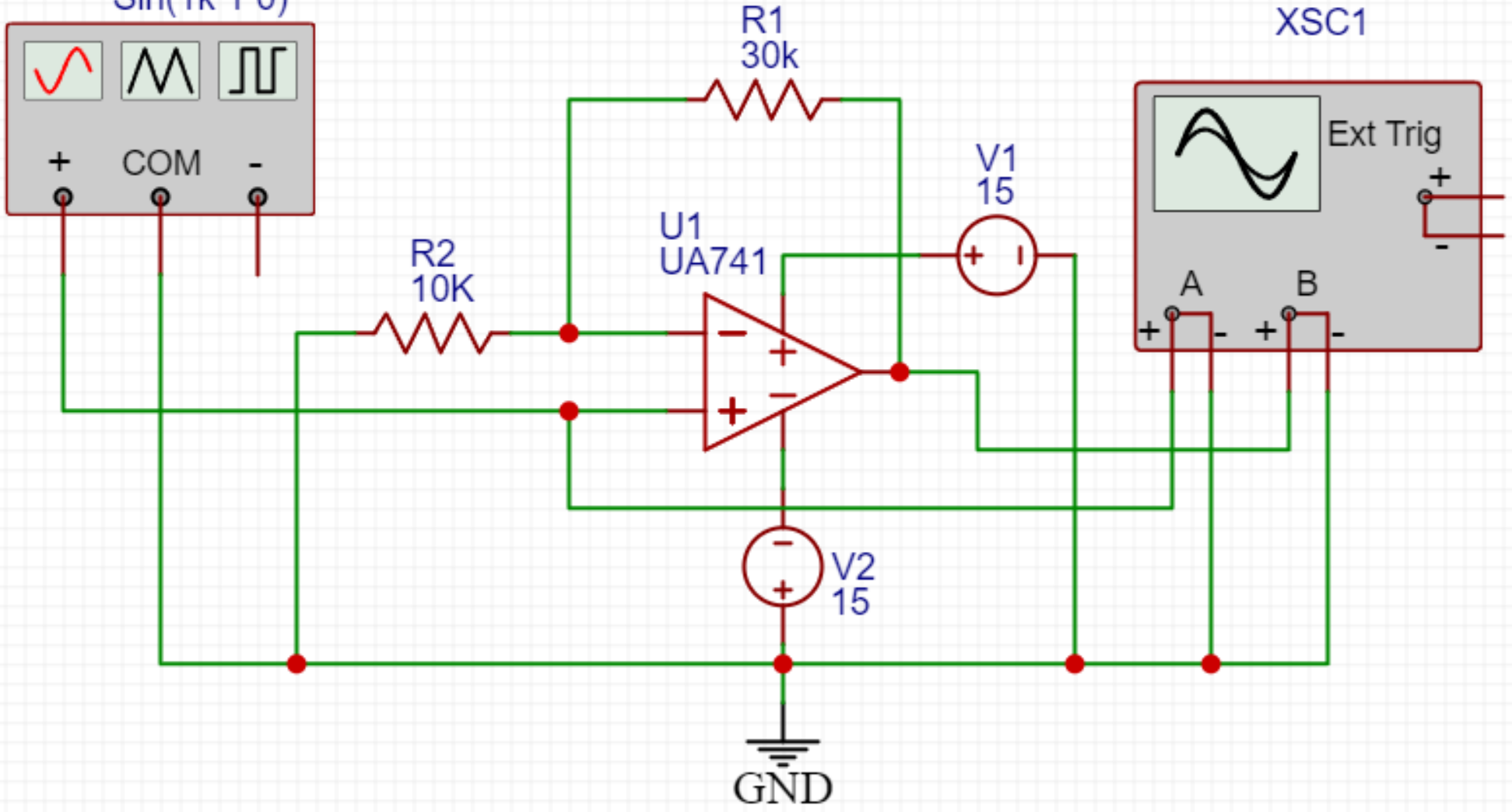


NON-INVERTING AMPLIFIER

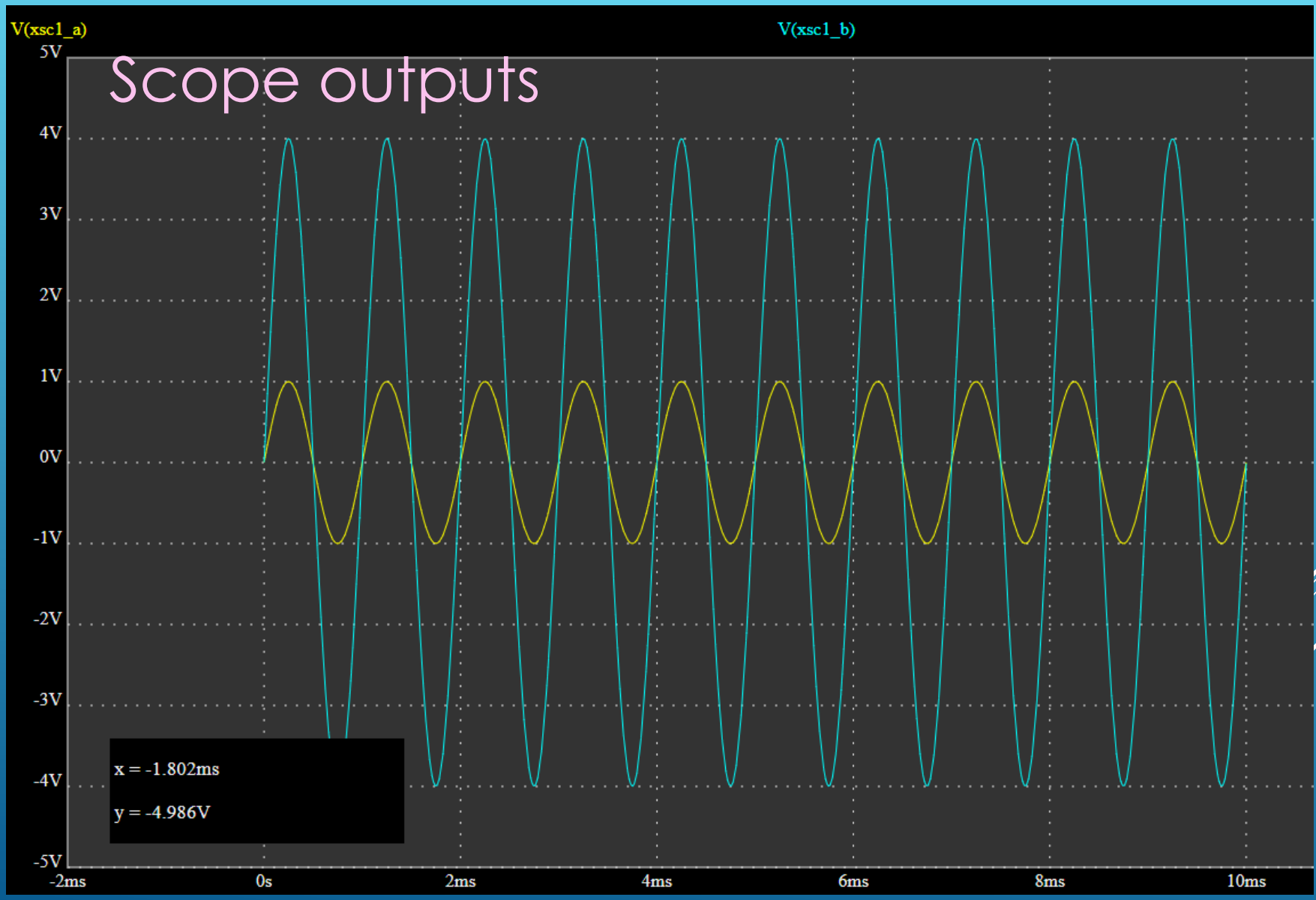
$$\frac{v_{out}}{v_S} = 1 + \frac{R_F}{R_S}$$



Non-inverting amp simulation

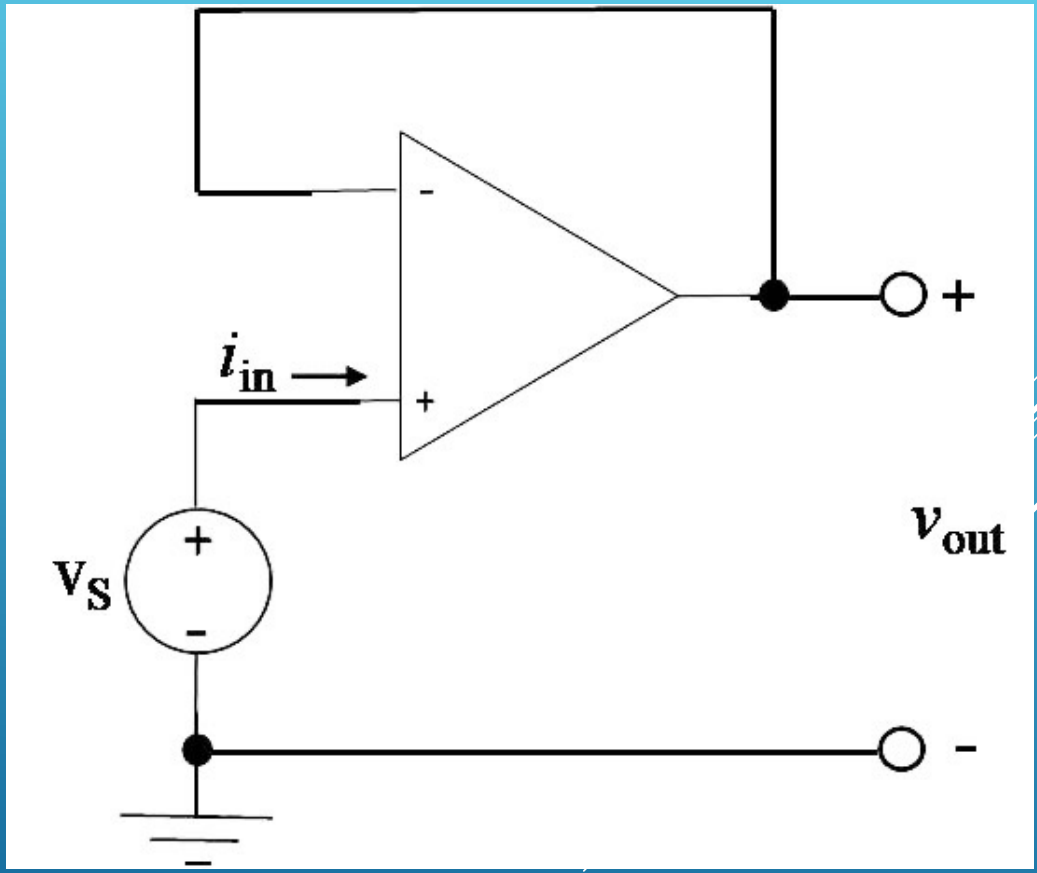


Scope outputs



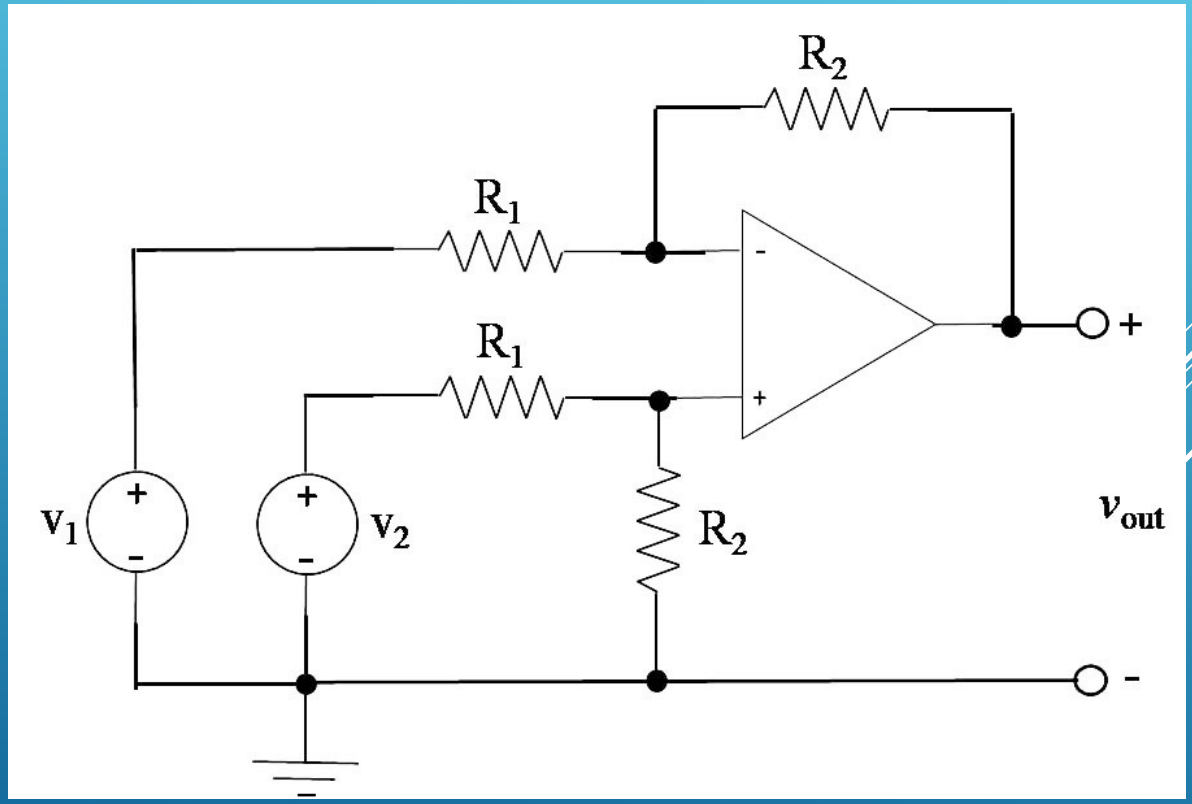
VOLTAGE FOLLOWER

$V_{out} = V_s$

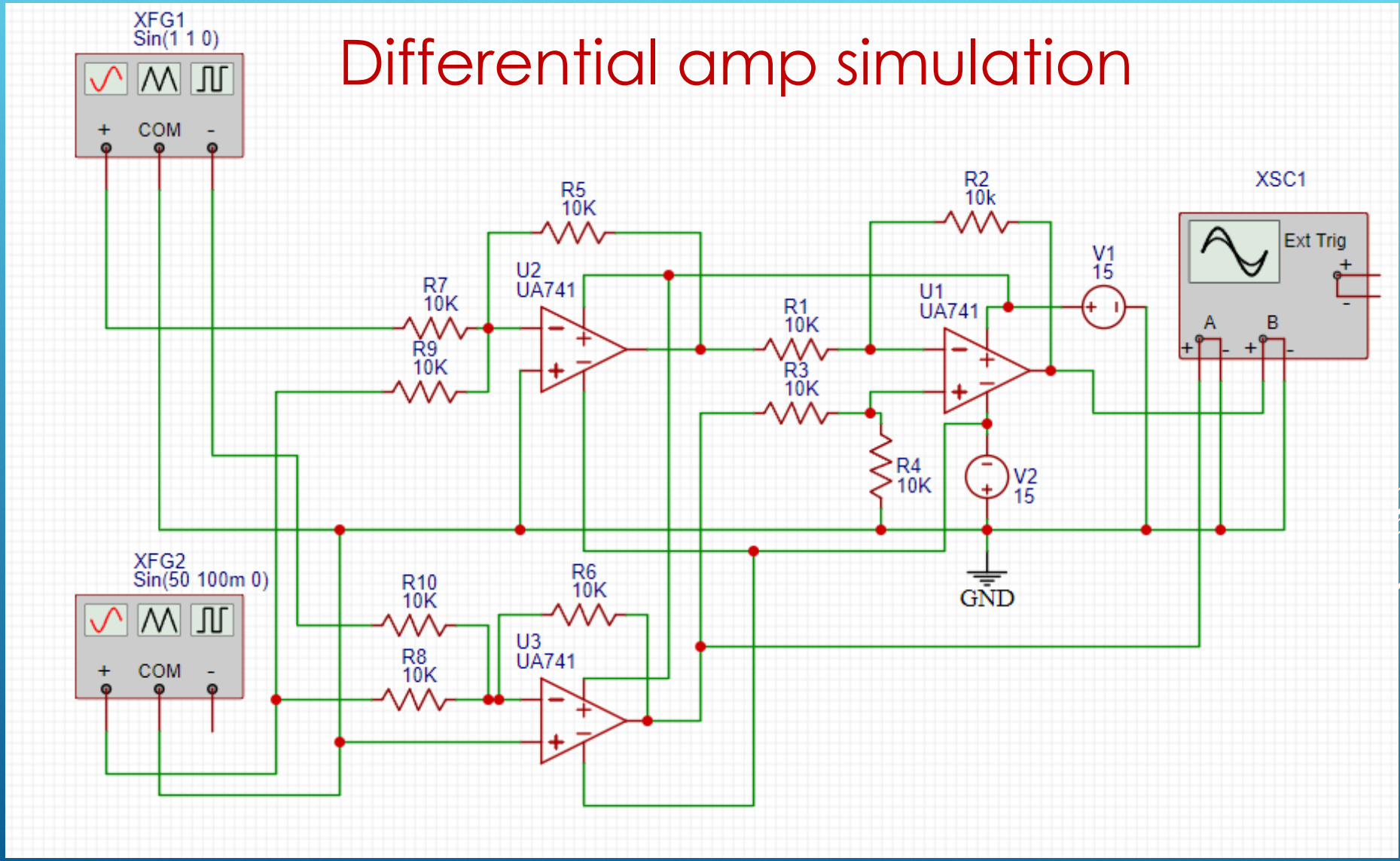


DIFFERENTIAL AMPLIFIER

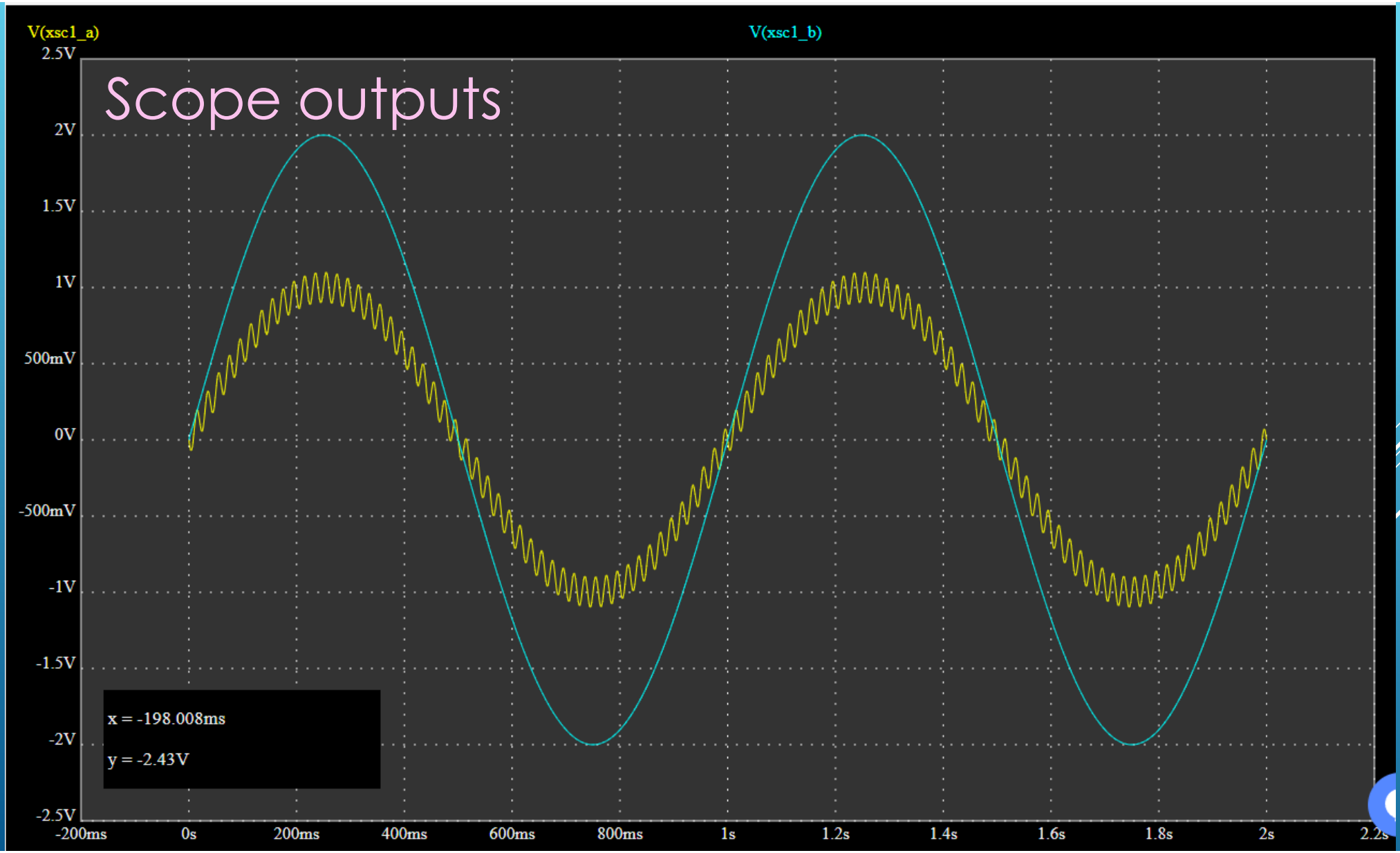
$$v_{out} = \frac{R_2}{R_1}(v_2 - v_1)$$



Differential amp simulation

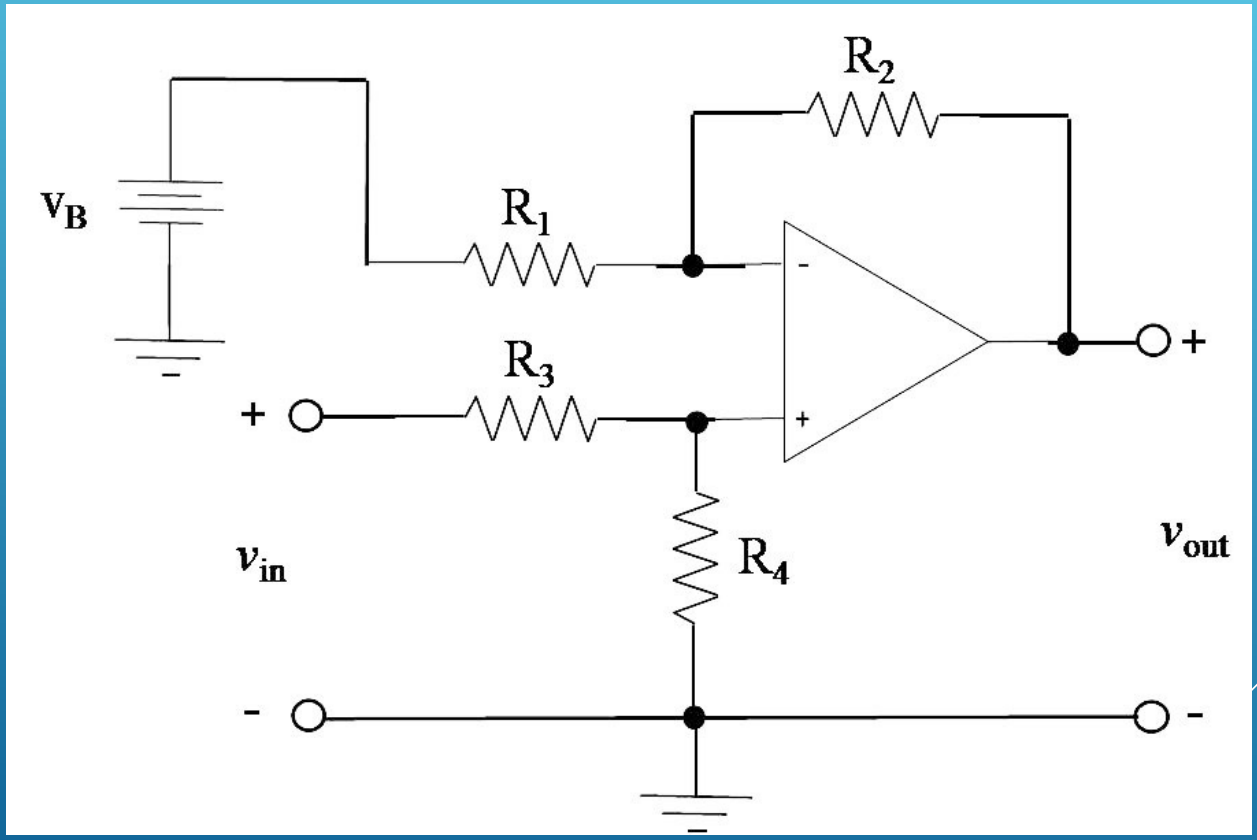


Scope outputs



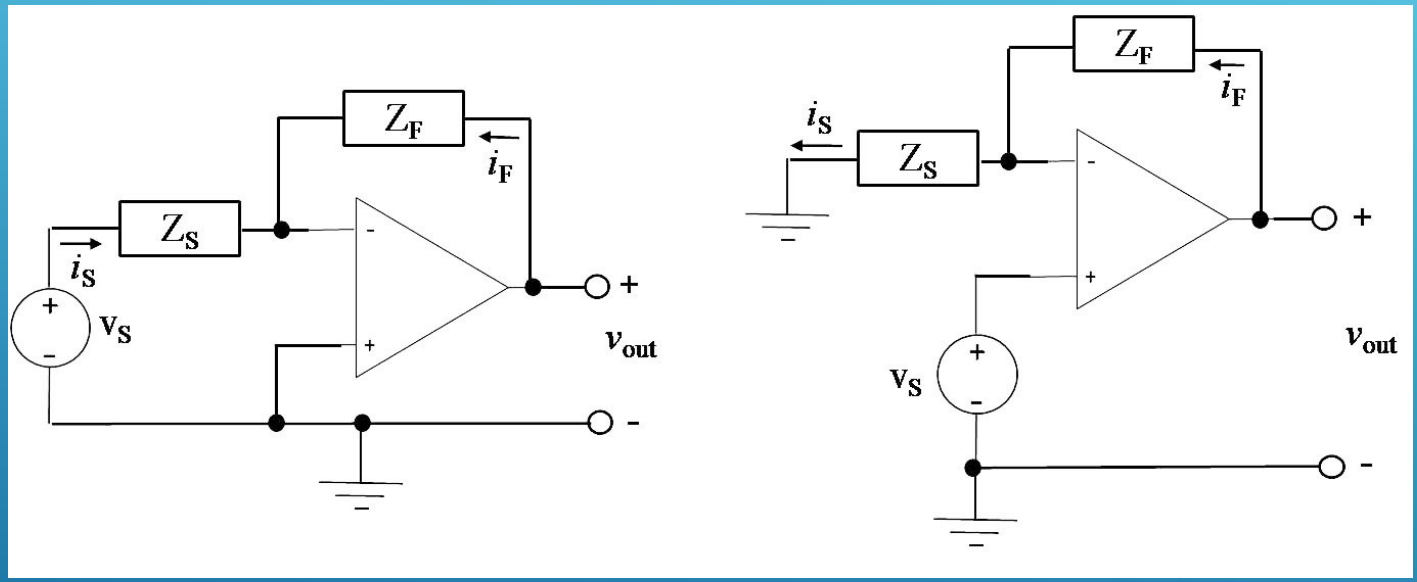
LEVEL SHIFTER

$$V_{out} = \left(\frac{R_4}{R_3 + R_4}\right)\left(1 + \frac{R_2}{R_1}\right)V_{in} - \left(\frac{R_2}{R_1}\right)V_B$$



Note: R3, R4 is not needed for Vout> Vin

OP-AMP CIRCUITS WITH IMPEDANCE



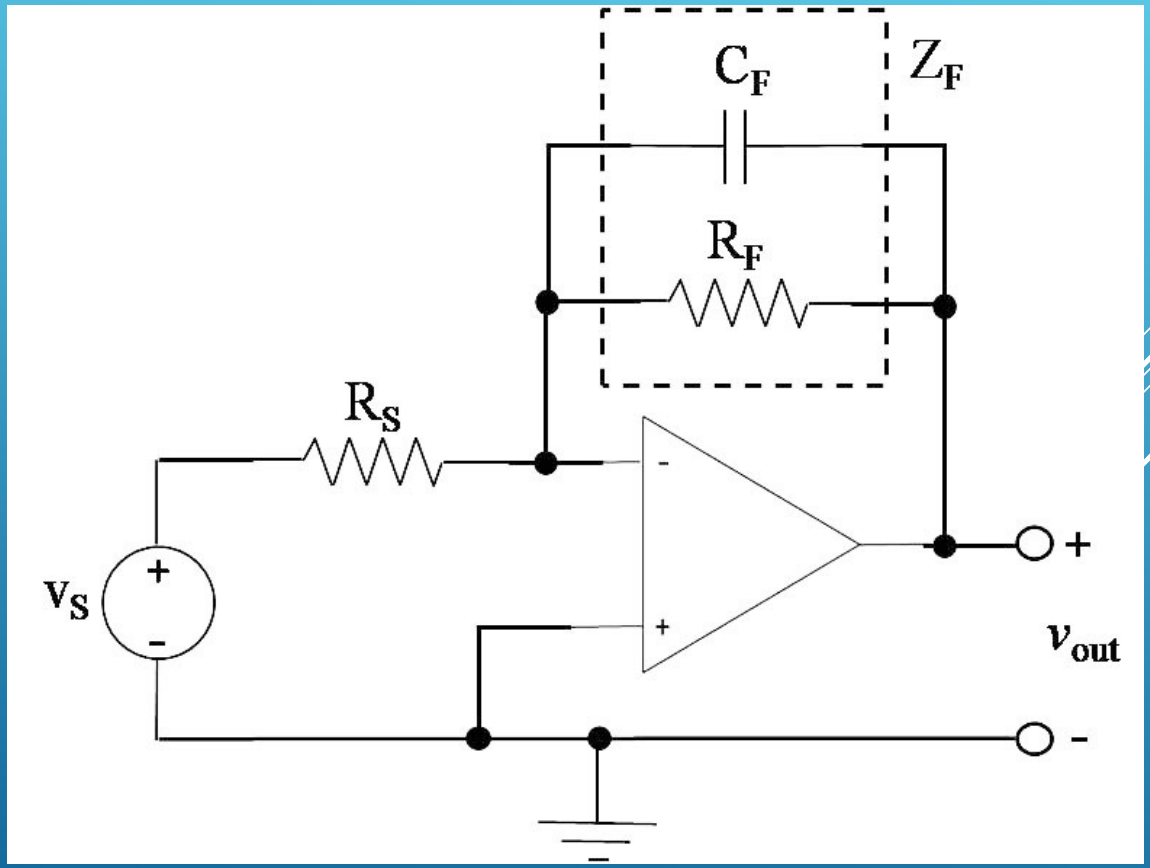
$$\frac{\mathbf{V}_{out}}{\mathbf{V}_S}(j\omega) = -\frac{Z_F}{Z_S}$$

$$\frac{\mathbf{V}_{out}}{\mathbf{V}_S}(j\omega) = 1 + \frac{Z_F}{Z_S}$$

ACTIVE LPF

$$A_{LPF}(j\omega) = -\frac{Z_F}{Z_S} = -\frac{R_F / R_S}{1 + j\omega C_F R_F}$$

$$\omega_o = \frac{1}{R_F C_F}$$

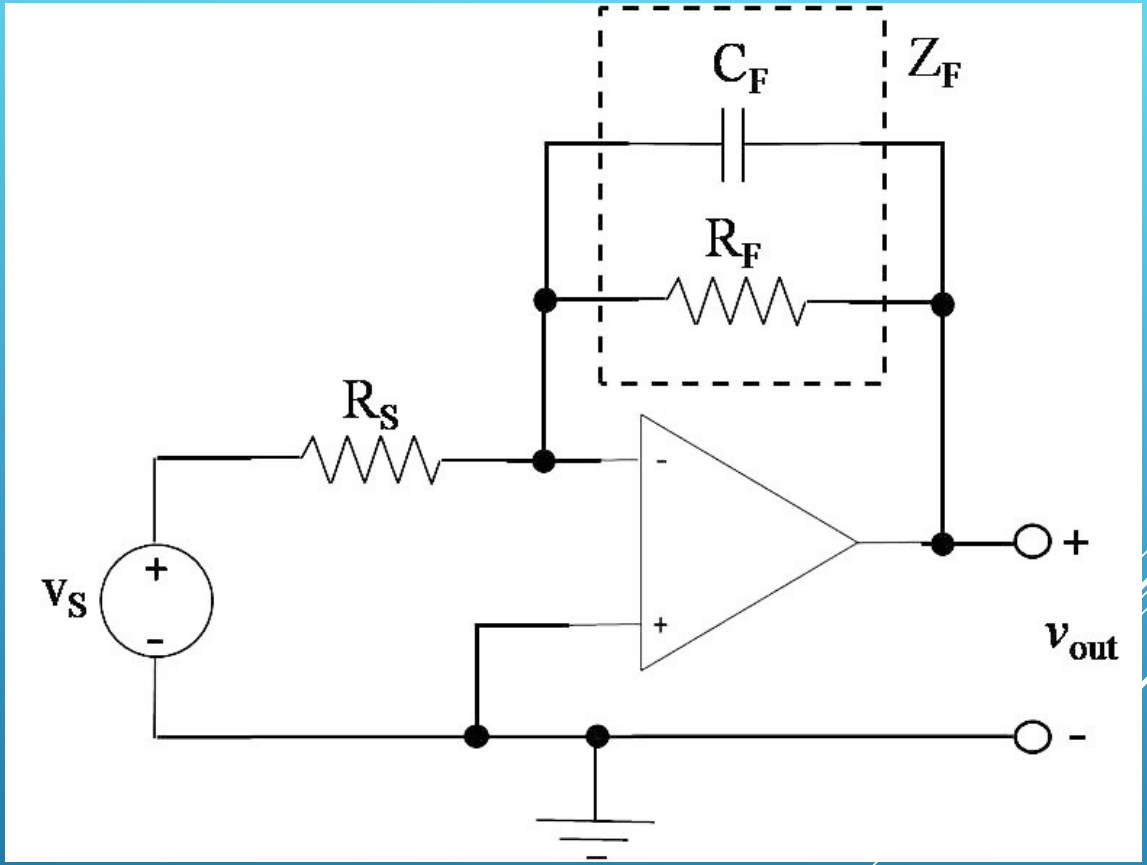


EXERCISE 1

Design active LPF with gain of -10
Signal frequency = 1 Hz
Noise frequency = 50 Hz

$$A_{LPF}(s) = -\frac{R_F/R_S}{C_F R_F s + 1}$$

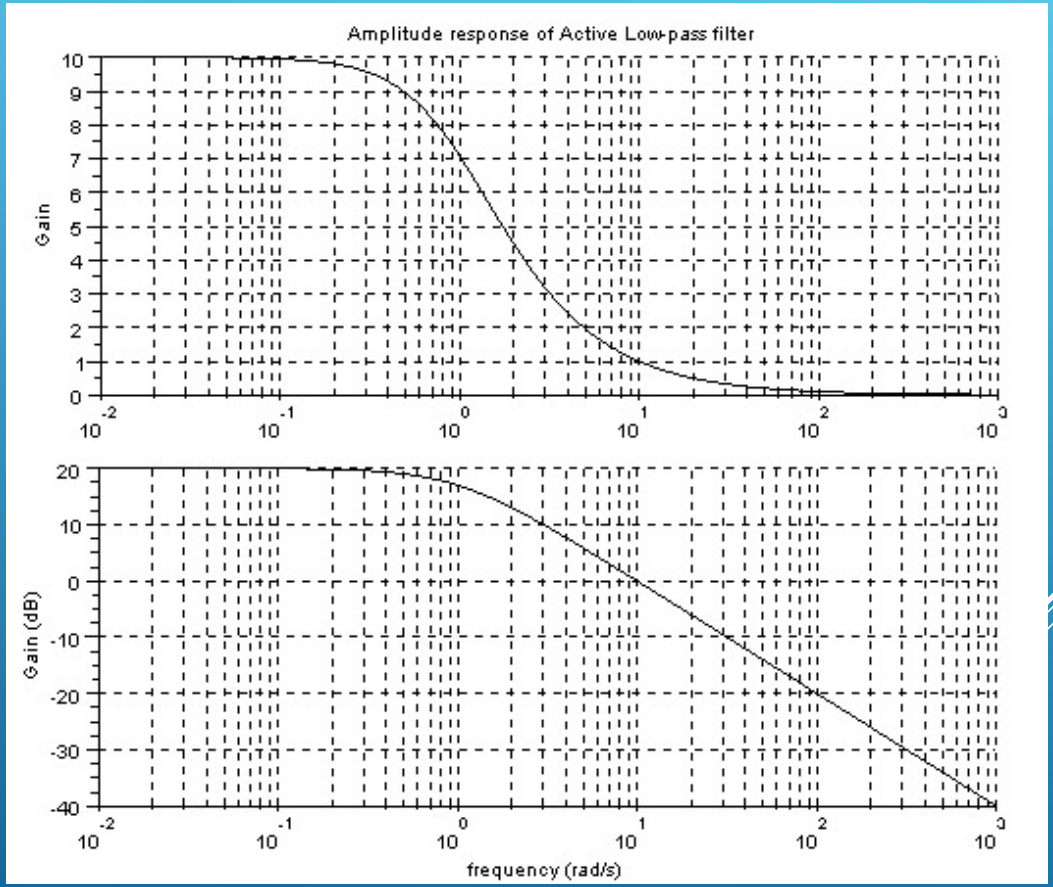
$$\omega_o = \frac{1}{R_F C_F}$$



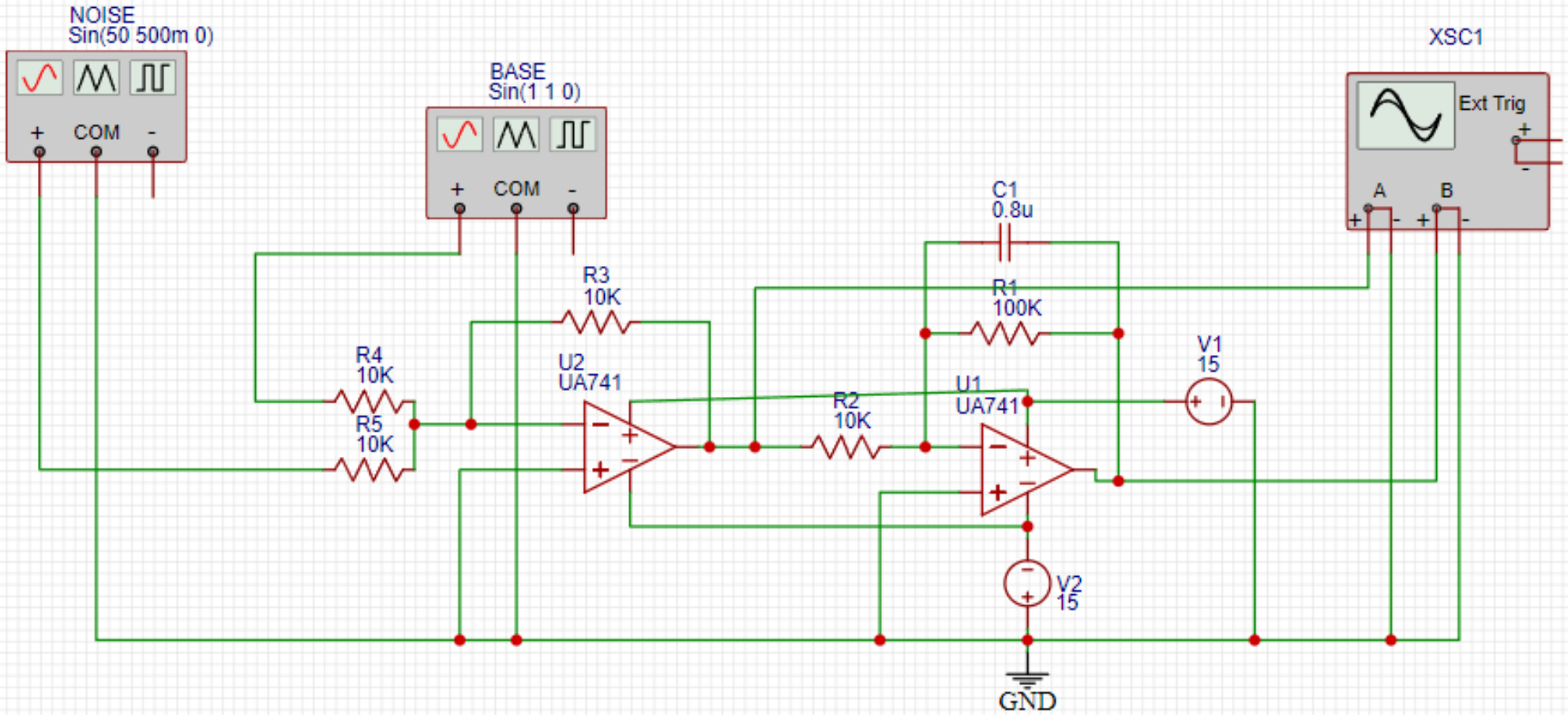
FREQUENCY RESPONSE OF ACTIVE LPF

R_S = 1 KΩ
R_F = 10 KΩ
C_F = 100 μF

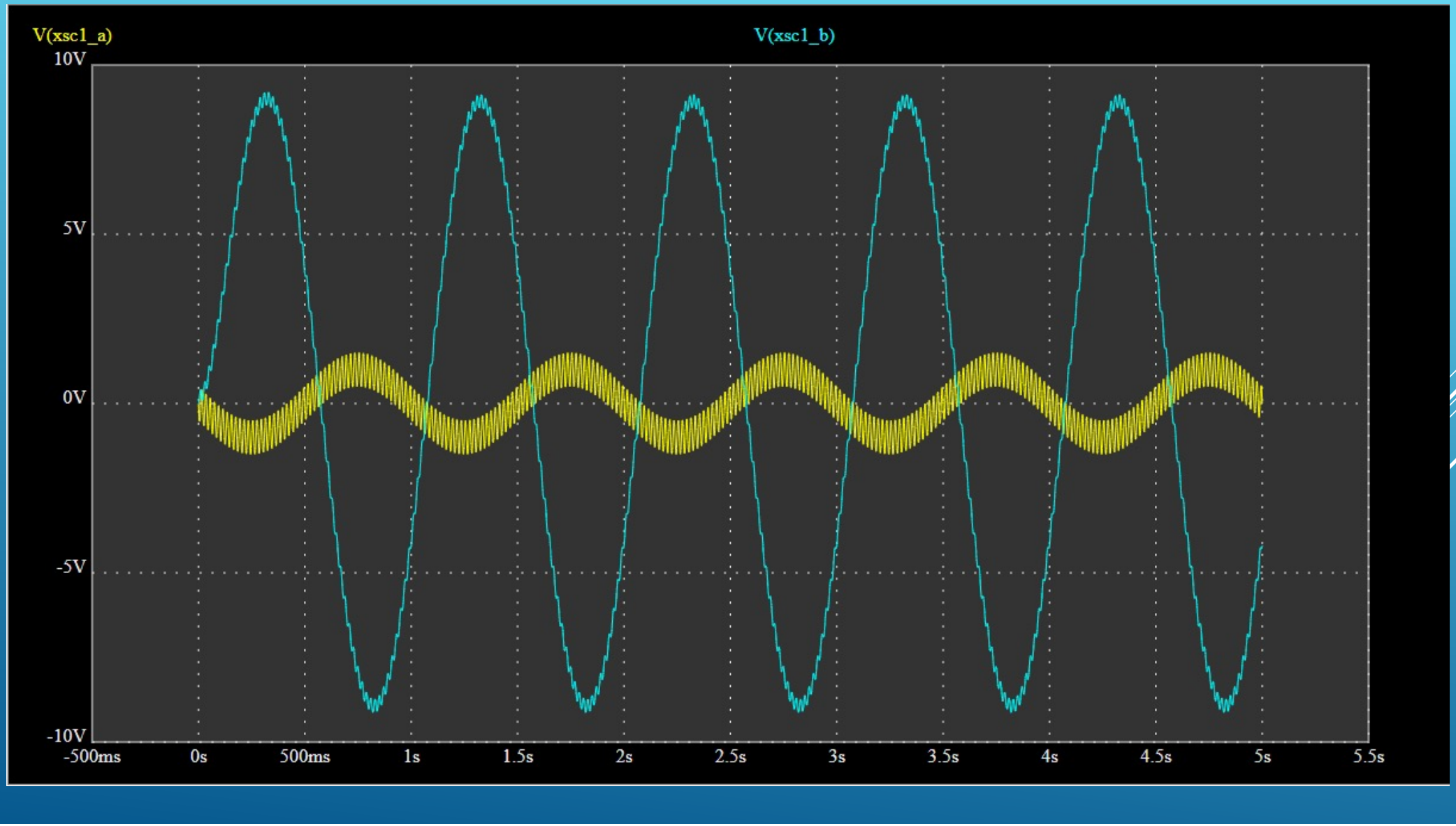
Gain = 10 (20 dB)
ω_0 = 1 rad/s



ALPF simulation

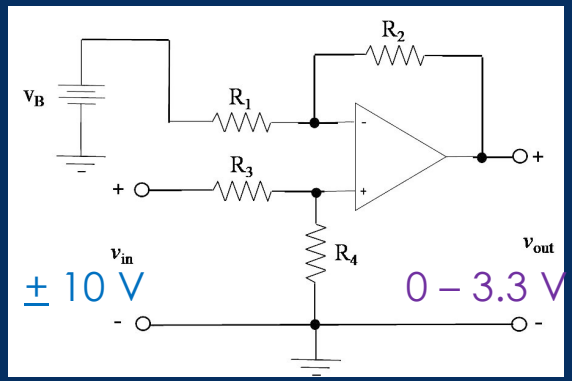


https://youtu.be/m3YYIChfxik?si=UBwR0yOs_MY2hcou


V(xsc1_a)
V(xsc1_b)
10V
5V
0V
-5V
-10V
-500ms
0s
500ms
1s
1.5s
2s
2.5s
3s
3.5s
4s
4.5s
5s
5.5s

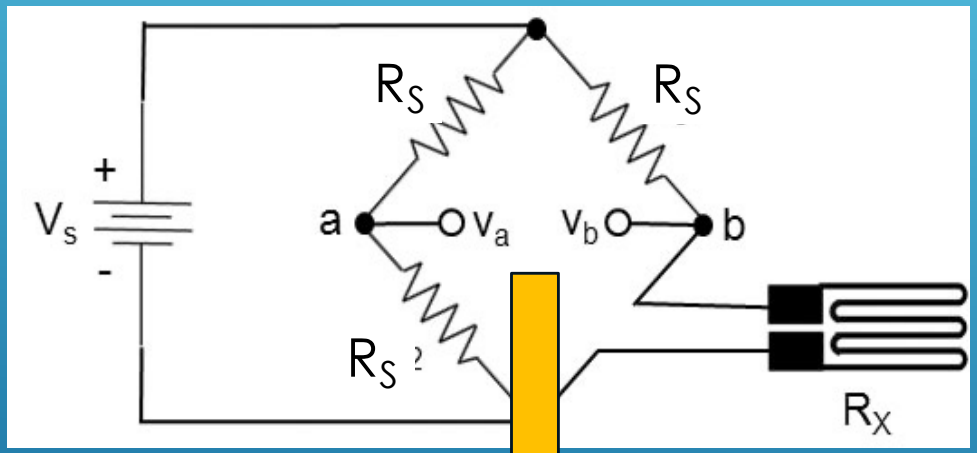
Ex 3.2:

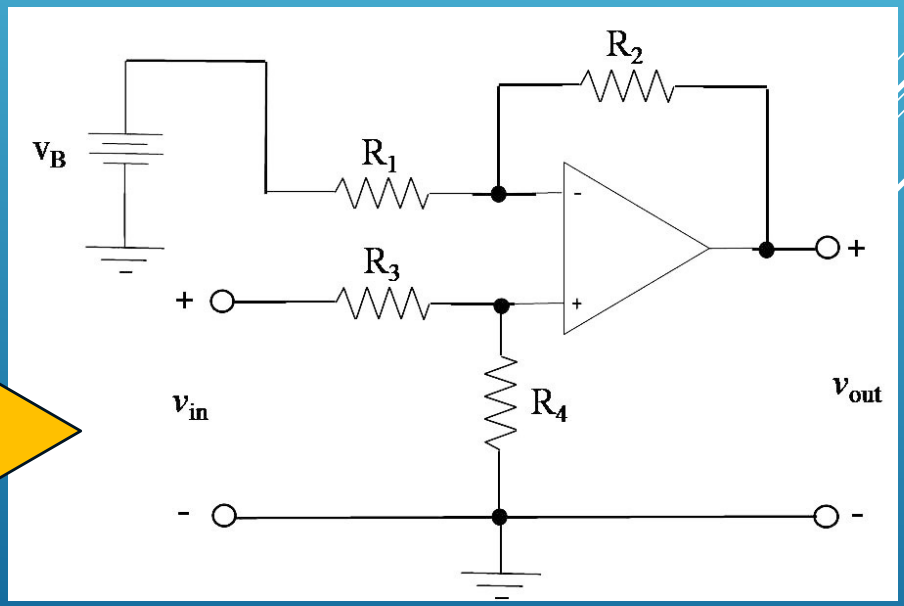
- Design a level shifter circuit that accepts sensor signal in the range ± 10 volt and convert to range 0 – 3.3 volt at output.



HW#3

- (Part 1) Design a level shifter circuit for the wheatstone bridge exercise in lecture 1

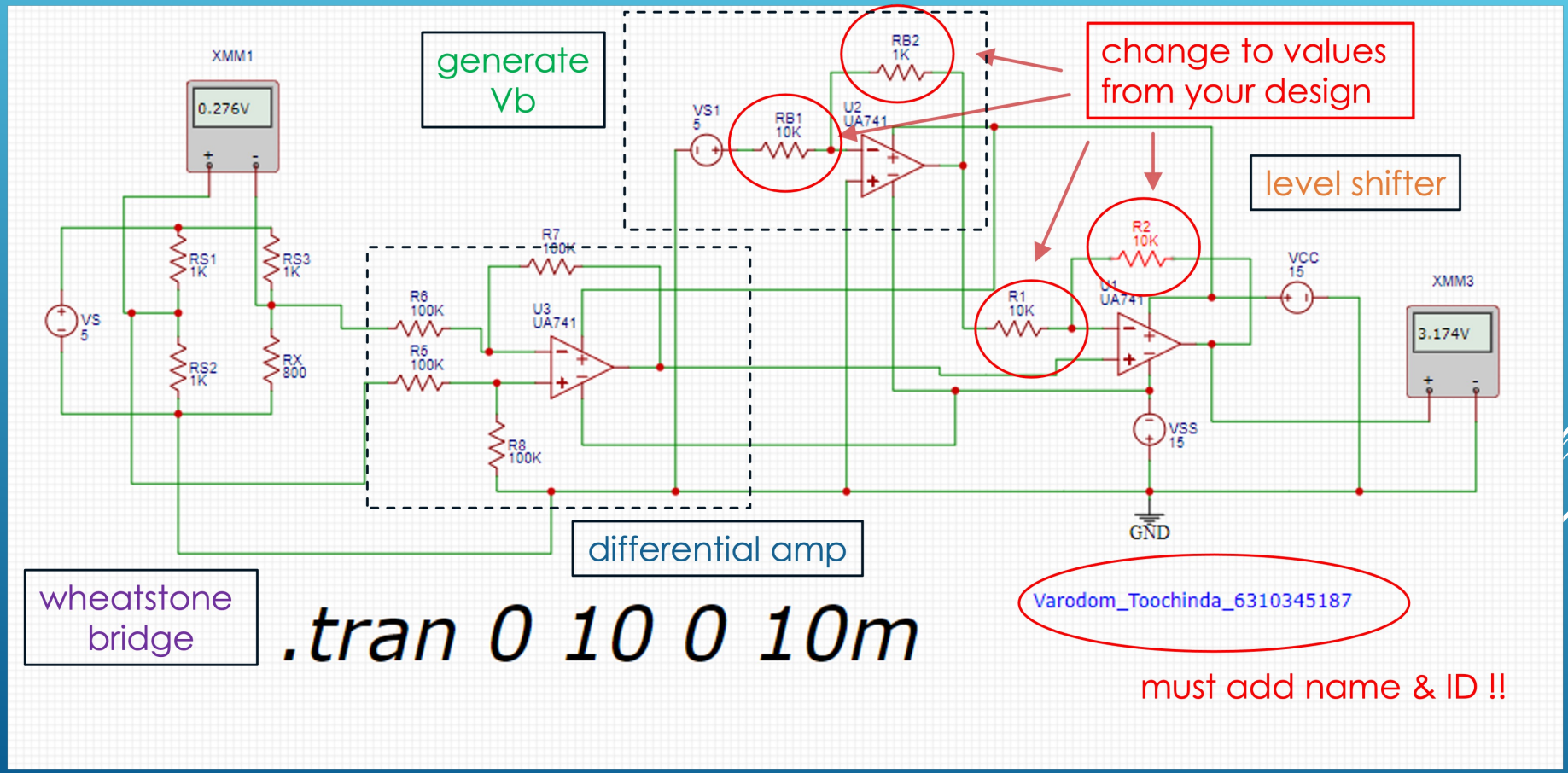




Let Vs = 5 Volts. Rs = 1000 Ohms, Rx varies between 800 – 1200 Ohms

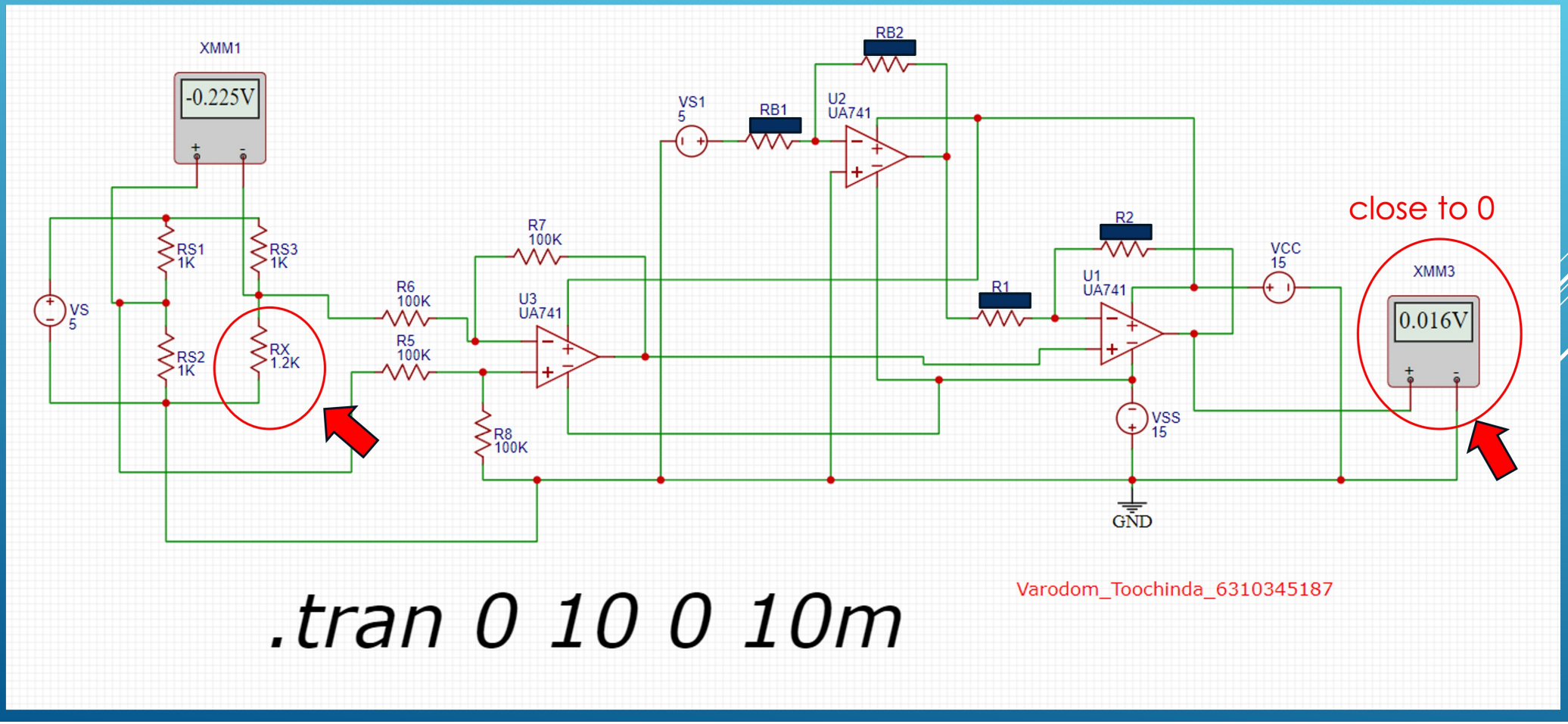
HW#3

- (Part 2) Construct a circuit on EasyEDA and simulate



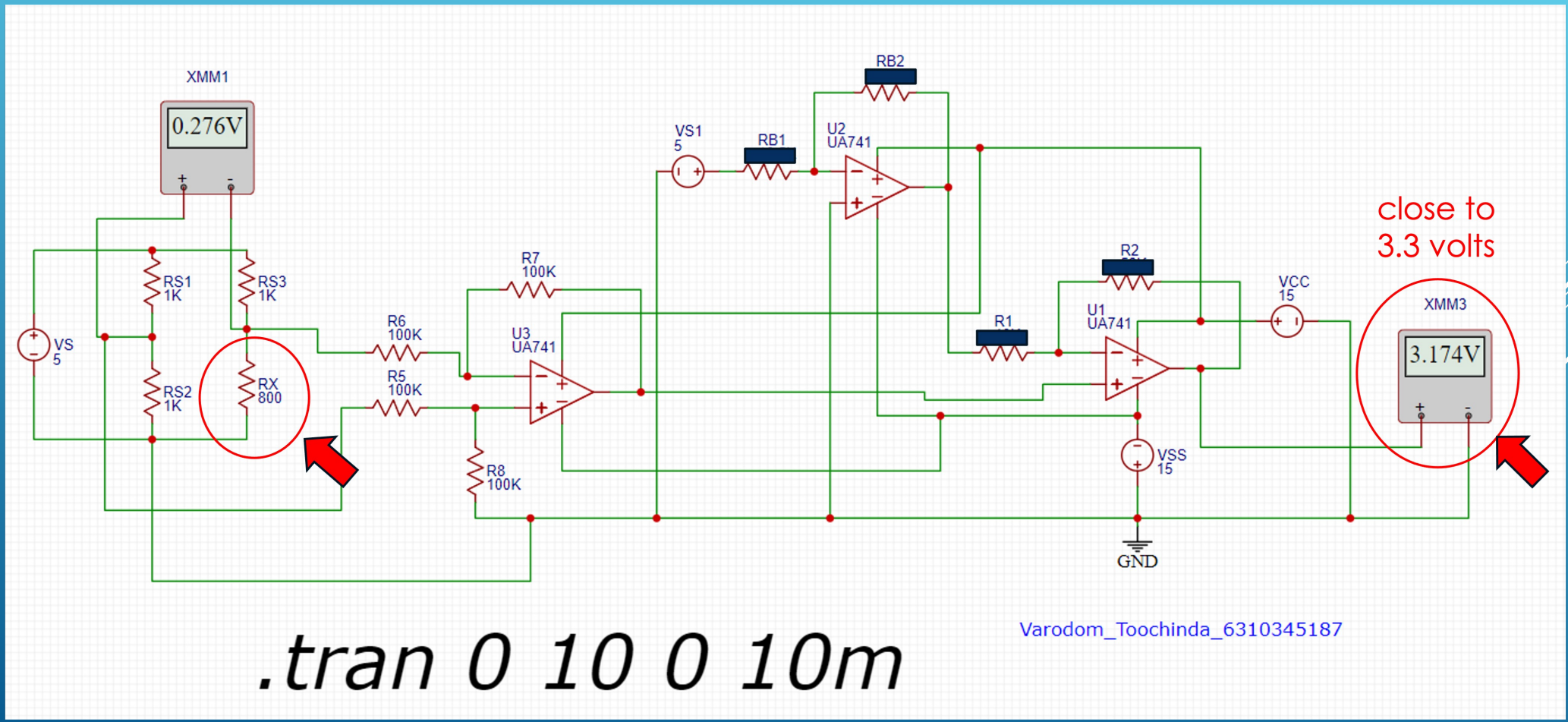
HW#3

- Expected output when Rx = 1200 Ohms

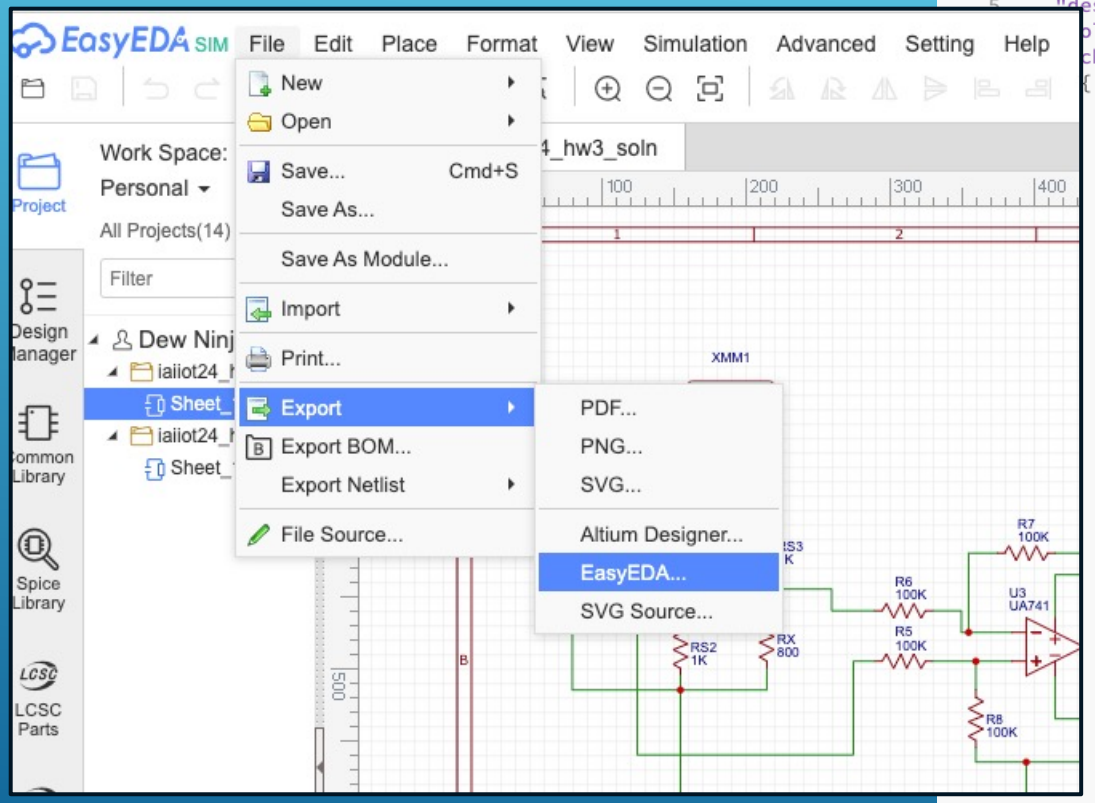


HW#3

- Expected output when Rx = 800 Ohms



Export EasyEDA json file

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```


Copy and paste code to notebook cell.
No code, no credit!