

# Comparator Applications 2

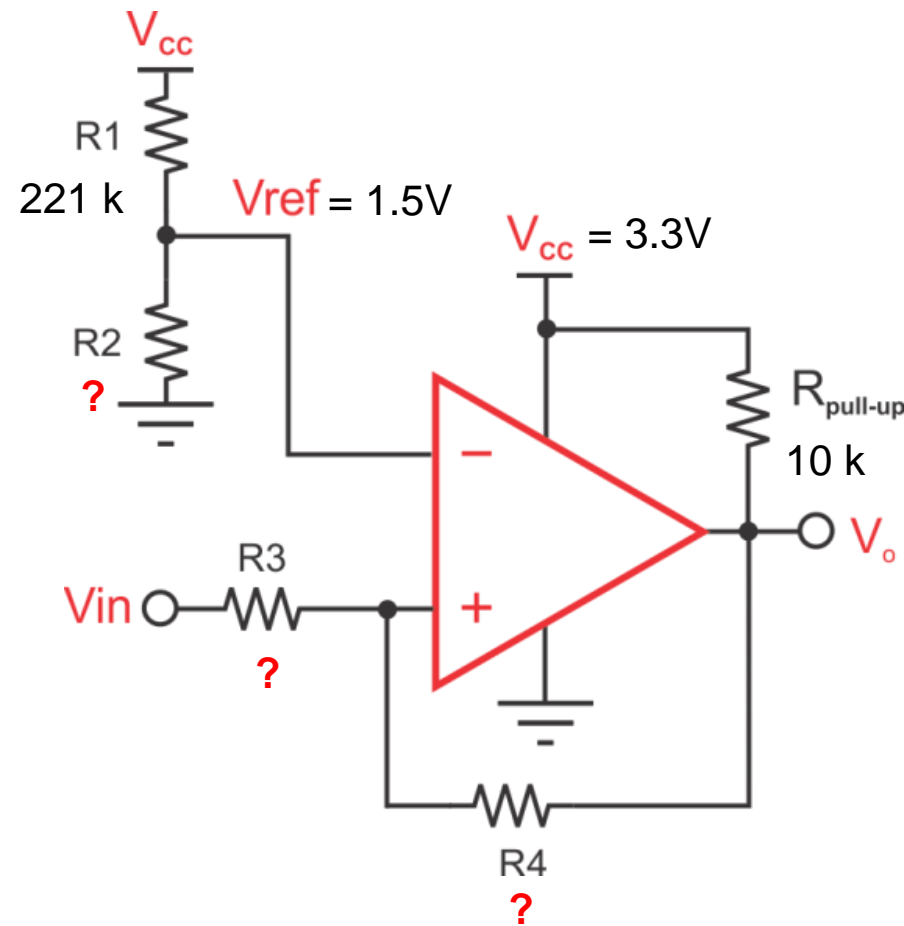
## Quiz

TIPL 2102

TI Precision Labs – Op Amps

# Question 1

- Design the non-inverting comparator with hysteresis circuit to meet the design goals.
- Verify with simulation in TINA-TI using the related file **2102\_Q1.tsc**



## Design goals

$$V_{\text{HYST}} = 200 \text{ mV}, \quad V_{\text{ref}} = 1.5 \text{ V}$$

## Starting values

$$V_{\text{cc}} = 3.3 \text{ V}, \quad V_{\text{O(max)}} = 3.3 \text{ V}, \quad V_{\text{O(min)}} = 50 \text{ mV}$$

$$R1 = 221 \text{ k}, \quad R_{\text{pull-up}} = 10 \text{ k}$$

## Calculate remaining values

$$R2 = ?, \quad R3 = ?, \quad R4 = ?$$

# Multiple Choice

- Noise can affect the operation of a comparator by \_\_\_\_\_.
  - a. Causing the output to rapidly change state
  - b. Changing the effective threshold voltage
  - c. Reducing the rise time and fall time
  - d. Both a. and b.
  
- Noise on which inputs of a comparator can affect its operation?
  - a. Input signal  $V_{IN}$  only
  - b. Reference signal  $V_{REF}$  only
  - c. Both  $V_{IN}$  and  $V_{REF}$
  - d. Neither  $V_{IN}$  nor  $V_{REF}$

# Multiple Choice

- Hysteresis is a form of \_\_\_\_\_ that \_\_\_\_\_.
  - a. Positive feedback; creates two distinct threshold levels
  - b. Positive feedback; creates a single noise-immune threshold level
  - c. Negative feedback; creates two distinct threshold levels
  - d. Negative feedback; creates a single noise-immune threshold level
  
- When designing a comparator circuit with external hysteresis, the amount of hysteresis should be \_\_\_\_\_.
  - a. Less than 10% of the hysteresis feedback resistor value
  - b. Greater than the maximum peak-to-peak noise you expect in your system
  - c. Less than the minimum peak-to-peak noise you expect in your system
  - d. Less than or equal to the built-in hysteresis of the comparator

# Solutions



# Question 1a – Solution

## Design goals

- $V_{\text{HYST}} = 200 \text{ mV}$
- $V_{\text{ref}} = 1.5 \text{ V}$

## Starting values

$$V_{\text{CC}} = 3.3 \text{ V}, \quad V_{\text{O(max)}} = 3.3 \text{ V}, \quad V_{\text{O(min)}} = 50 \text{ mV}$$

$$R1 = 221 \text{ k}, \quad R_{\text{pull-up}} = 10 \text{ k}$$

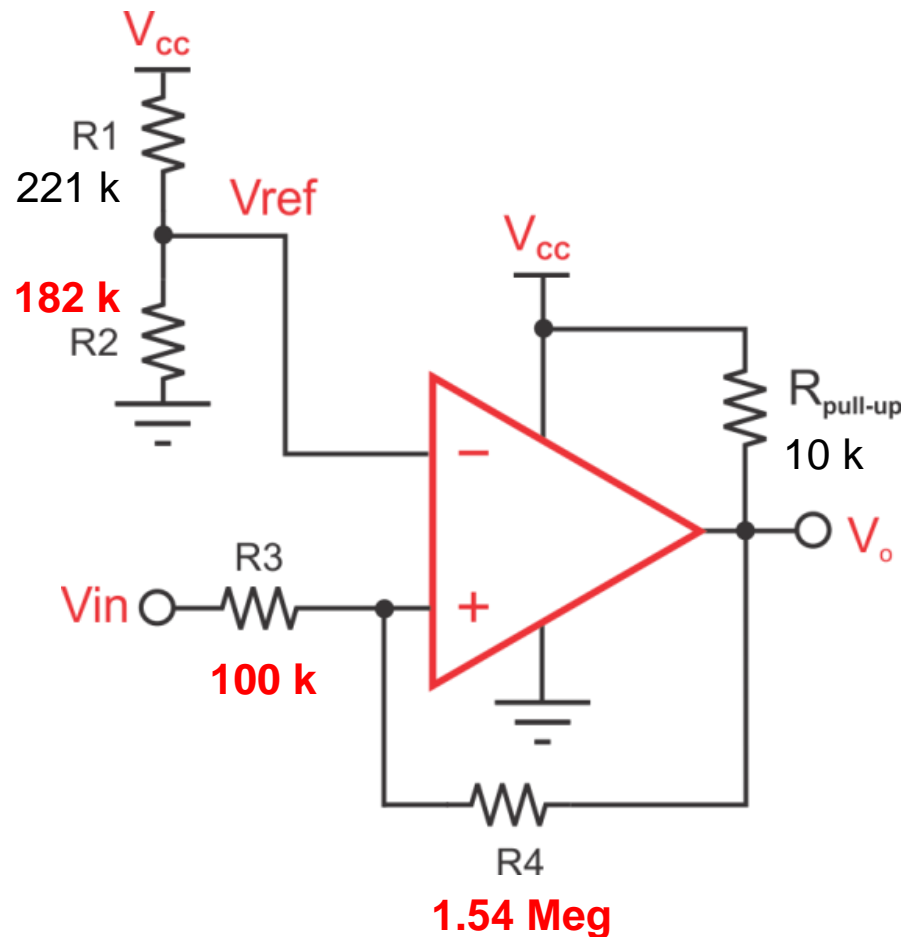
## Calculate remaining values

$$R2 = \frac{R1}{\left(\frac{V_{\text{CC}}}{V_{\text{ref}}} - 1\right)} = \frac{221 \text{ k}}{\left(\frac{3.3}{1.5} - 1\right)} = 184.2 \text{ k} = \mathbf{182 \text{ k}} \text{ (nearest 1\% value)}$$

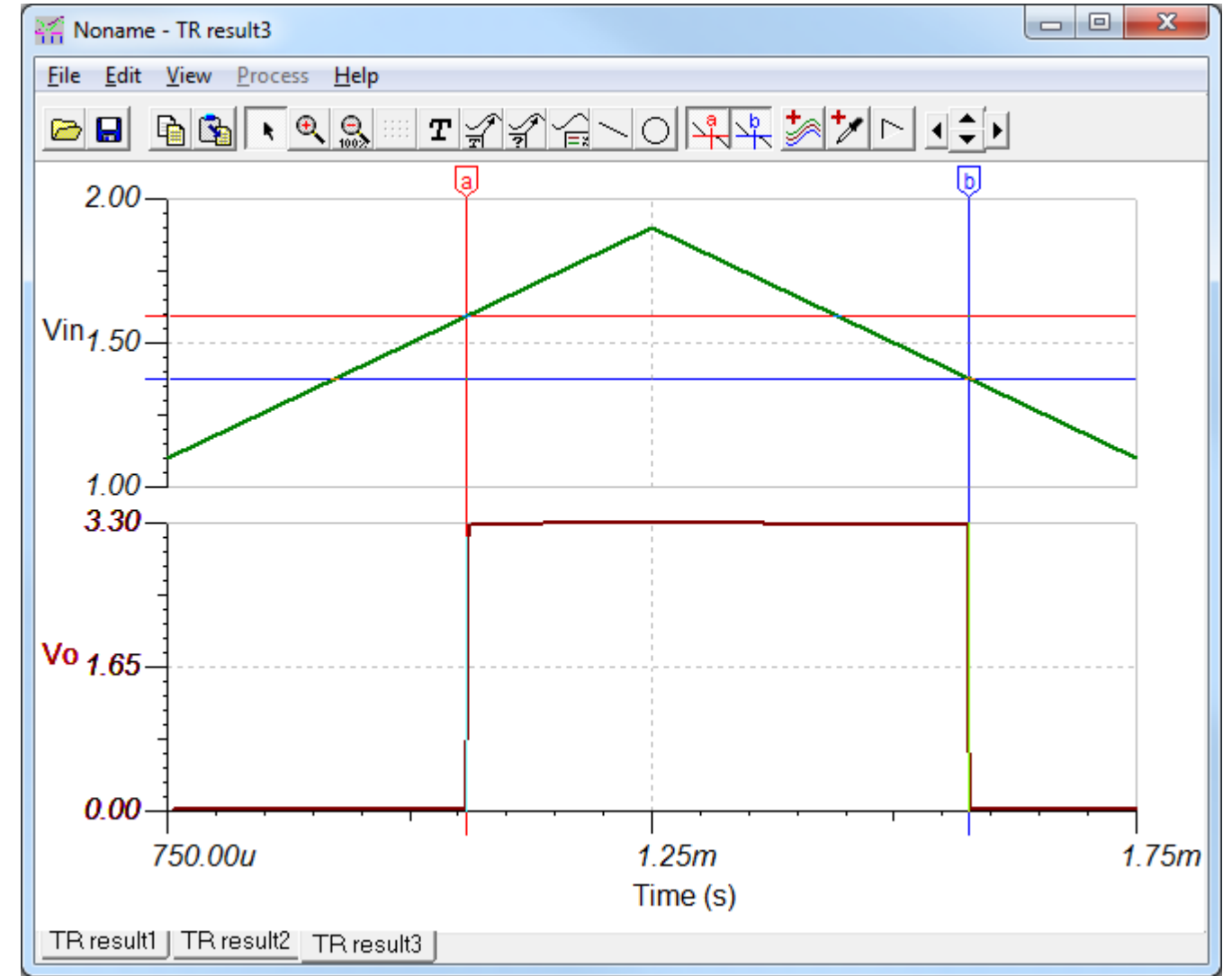
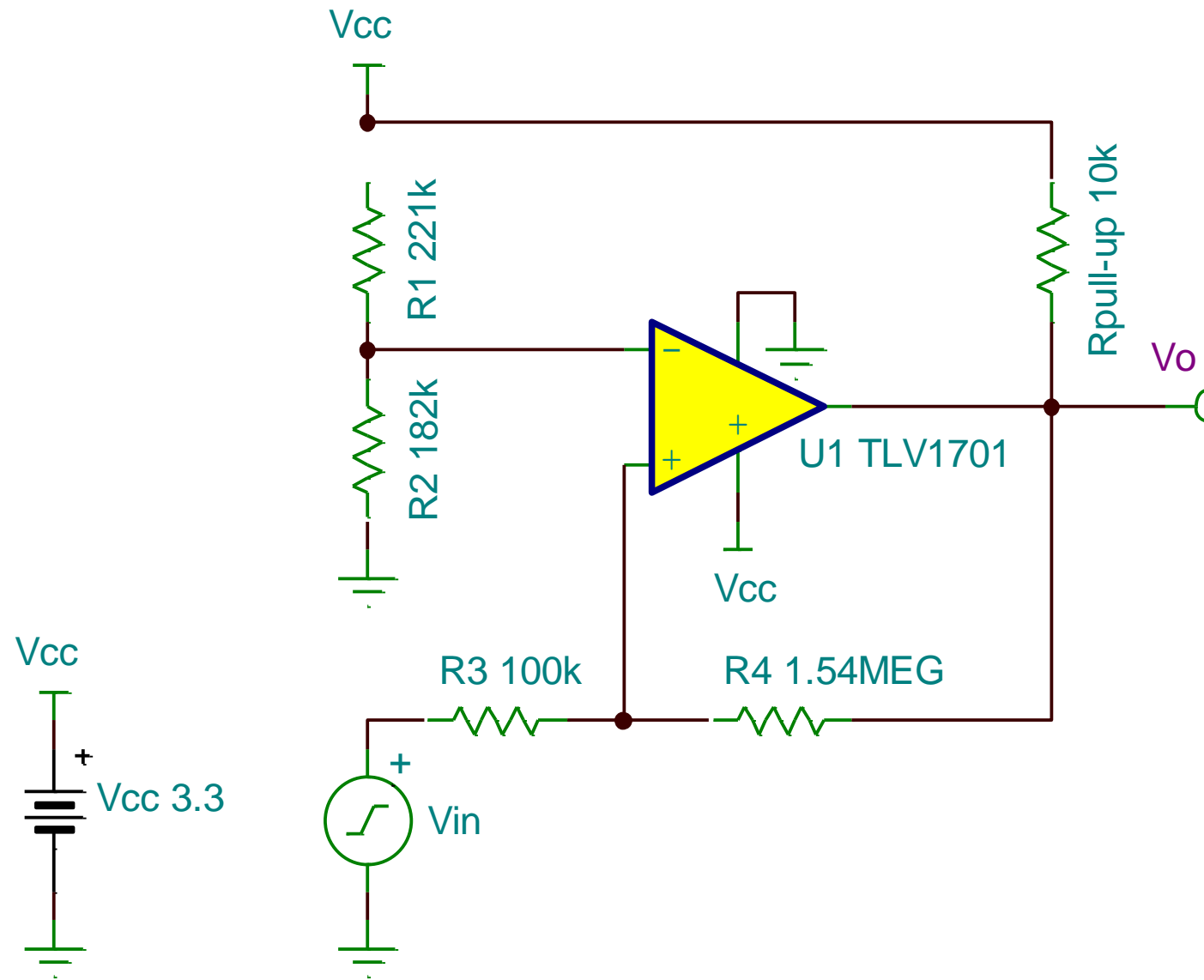
$$R3 = \frac{(R1 \cdot R2)}{(R1 + R2)} = \frac{(221 \text{e}3 \cdot 182 \text{e}3)}{(221 \text{e}3 + 182 \text{e}3)} = 99.8 \text{ k} = \mathbf{100 \text{ k}} \text{ (nearest 1\% value)}$$

$$R4 = R3 \left[ \frac{(V_{\text{O(max)}} - V_{\text{O(min)}})}{V_{\text{HYST}}} - 1 \right] = 100 \text{e}3 \left[ \frac{(3.3 - 0.05)}{200 \text{e-}3} - 1 \right]$$

$$R4 = 1.53 \text{ Meg} = \mathbf{1.54 \text{ Meg}} \text{ (nearest 1\% value)}$$



# Question 1b – Solution



A	x: 1.0589m	y: 1.5942
B	x: 1.5763m	y: 1.378
A - B	x: -517.3745u	y: 216.2162m

**216 mV** of hysteresis  
(some error caused by 1% resistor values)

# Multiple Choice – Solutions

- Noise can affect the operation of a comparator by \_\_\_\_\_.
  - a. Causing the output to rapidly change state
  - b. Changing the effective threshold voltage
  - c. Reducing the rise time and fall time
  - d. Both a. and b.
  
- Noise on which inputs of a comparator can affect its operation?
  - a. Input signal  $V_{IN}$  only
  - b. Reference signal  $V_{REF}$  only
  - c. Both  $V_{IN}$  and  $V_{REF}$
  - d. Neither  $V_{IN}$  nor  $V_{REF}$



# Multiple Choice – Solutions

- Hysteresis is a form of \_\_\_\_\_ that \_\_\_\_\_.
  - a. Positive feedback; creates two distinct threshold levels
  - b. Positive feedback; creates a single noise-immune threshold level
  - c. Negative feedback; creates two distinct threshold levels
  - d. Negative feedback; creates a single noise-immune threshold level
- When designing a comparator circuit with external hysteresis, the amount of hysteresis should be \_\_\_\_\_.
  - a. Less than 10% of the hysteresis feedback resistor value
  - b. Greater than the maximum peak-to-peak noise you expect in your system
  - c. Less than the minimum peak-to-peak noise you expect in your system
  - d. Less than or equal to the built-in hysteresis of the comparator