Lesson 5: Window Comparators

ET 438b Sequential Control and Data Acquisition

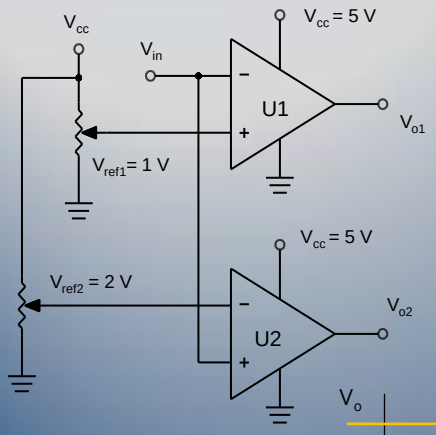
Department of Technology

Learning Objectives

After this presentation you will be able to:

- Explain how a window comparator operates
- Construct a window comparator using OP AMPs
- Use a window comparator to detect voltages in three ranges
- Design a window comparator given values of upper and lower trip voltages.

Window Comparators

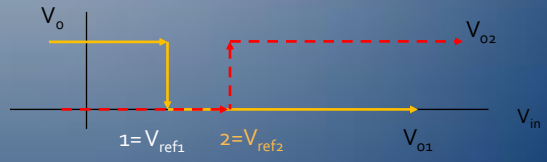


Circuit Logic U_1 Inverting Comparator

$V_{in} > V_{ref1}$ (1 V) then $V_{o1} = 0$ V
$V_{in} < V_{ref1}$ (1 V) then $V_{o1} = V_{cc}$ (5 V)

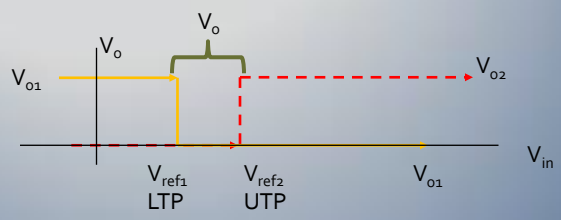
Circuit Logic U_2 Non-Inverting Comparator

$V_{in} > V_{ref2}$ (2 V) then $V_{o2} = V_{cc}$ (5 V)
$V_{in} < V_{ref2}$ (2 V) then $V_{o2} = 0$ V



Window Comparators

Add outputs through logic gates to get final V_o Assume V_{cc} = 5

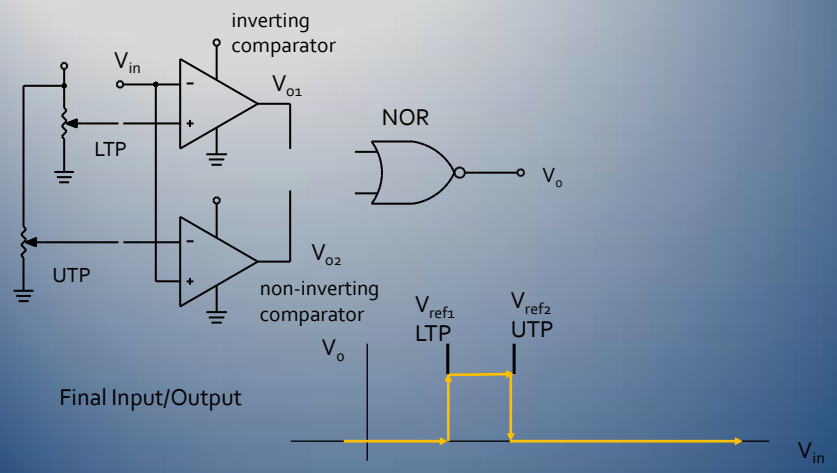


V_{o1}	V_{o2}	V_o	
0	0	5	when LTP< V_{in} < UTP
0	5	0	when V_{in} > UTP
5	0	0	when V_{in} < LTP
5	5	0	this case never happens

Same logic as NOR gate.

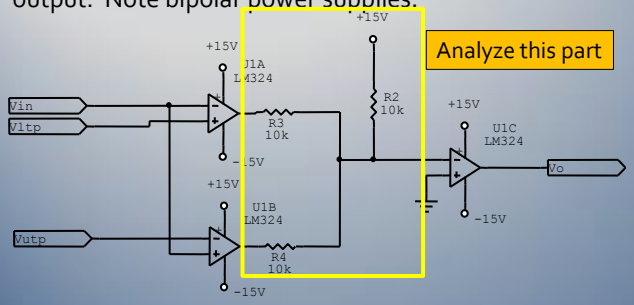
Window Comparator

Final Circuit



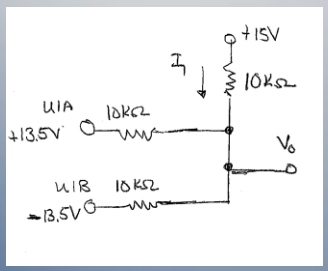
Window Comparator-Alternate Design

Add outputs using resistive voltage dividers and use OP AMP for final output. Note bipolar power supplies.

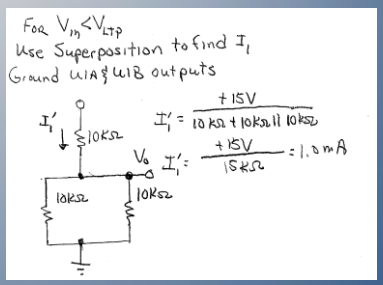


Window Comparator-Alternate Design Analysis

Circuit enclosed

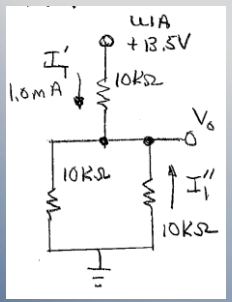


Must use superposition



Find Contribution from U1A OUTPUT
Total current $I_1' = 1.0mA$ from above calculations

Window Comparator-Alternate Design Analysis

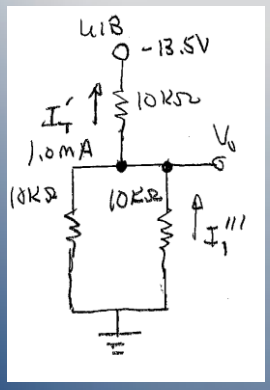


$$I_1'' = -1.0mA\left[\frac{10K\Omega}{10K\Omega + 10K\Omega}\right] = (-1.0mA)(0.5)$$

$$I_1'' = -0.5mA$$

Find Contribution from U1B output (-13.5V)
$I_1' = 1.0mA$ from analysis above
pos. due to flow in same direction as assumed I_1

Window Comparator-Alternate Design Analysis



$I_1''' = (1.0mA)\left[\frac{10K\Omega}{10K\Omega + 10K\Omega}\right]$

$I_1''' = (1.0mA)(0.5) = 0.5mA$

Find I_T $\quad I_T = I_1' + I_2'' + I_3''' = 1.0mA - 0.5mA + 0.5mA$

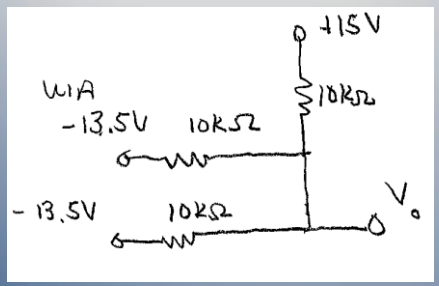
$I_T = 1.0mA$

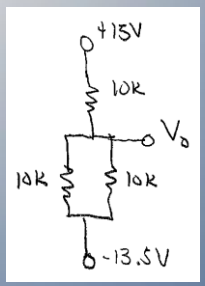
Find drop from +15V supply to V_o

$V_o = +15 - (1mA)(10K\Omega) = 15 - 10 = +5Vdc$ when $V_{in} < V_{LTP}$

Window Comparator-Alternate Design Analysis

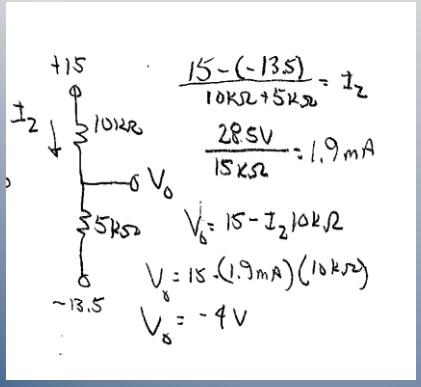
For $V_{LTP} < V_{in} < V_{UTP}$ the following circuit applies

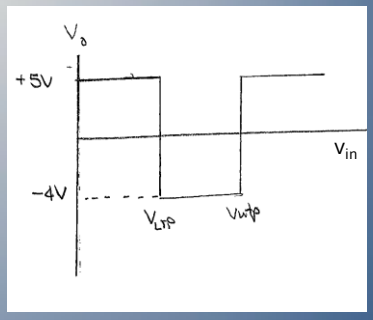




This can be further reduced

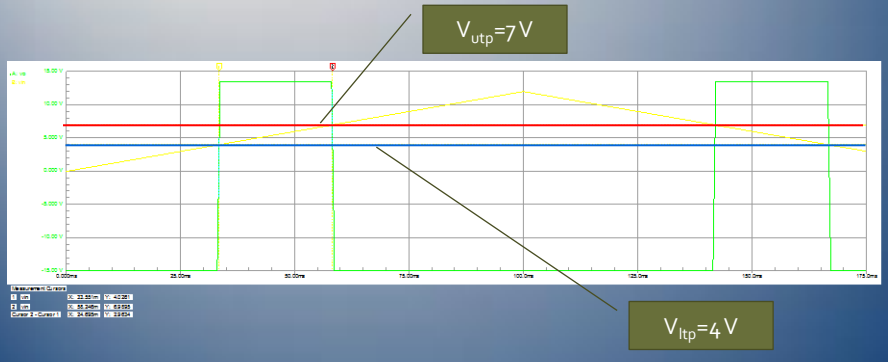
Window Comparator-Alternate Design Analysis





Window Comparator Simulation

Simulation of previous circuit using piece-wise linear input and transient analysis. Uses LM 324 Quad OP AMP. (4 in 1 package)



Design Example

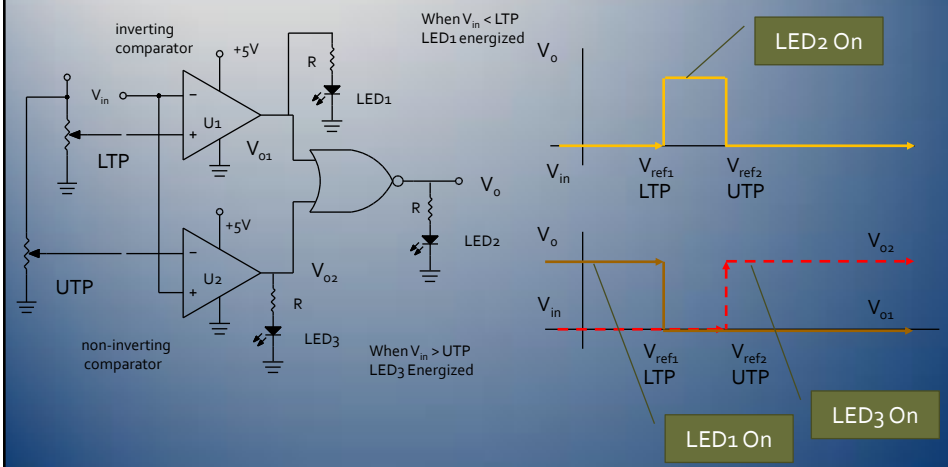
Design a circuit that will light one of three LEDs when the output from a pressure sensor that has a gain of .25 V/psi is connected to its input. The output should follow the specification listed below

Range	LED1	LED2	LED3
0 - 5 psi	on	off	off
5 - 10 psi	off	on	off
10 - 15 psi	off	off	on

Assume there is a 5Vdc power supply available and that all inputs and output are TTL compatible

Design Example

Solution: Use window comparator with LEDs connected to the outputs of each device in the circuit.



Design Example (Continued)

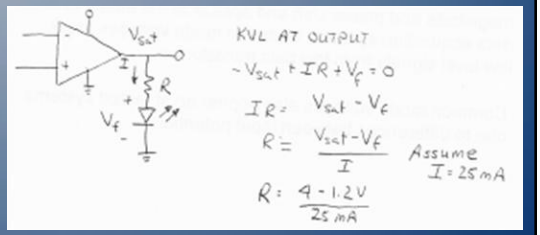
Determine the values of UTP and LTP from the pressure sensor gain.

Ranges
0 - 5 psi
5 - 10 psi
10 - 15 psi

$V_{LTP} = 5 \cdot (0.25\ V/psi) = 1.25\ V$
$V_{UTP} = 10 \cdot (0.25\ V/psi) = 2.5\ V$

Size resistors for LED current limiting. Determine the maximum current sourcing ability of the comparators. (assume 25 mA) Forward voltage drop of LEDs $V_f = 1.2\ V$

V_{sat} of U1 , U2 -0.8V_{cc}=4 V at high output



End Lesson 5: Window Comparators

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