Analog Engineer's Circuit

Comparator With and Without Hysteresis Circuit

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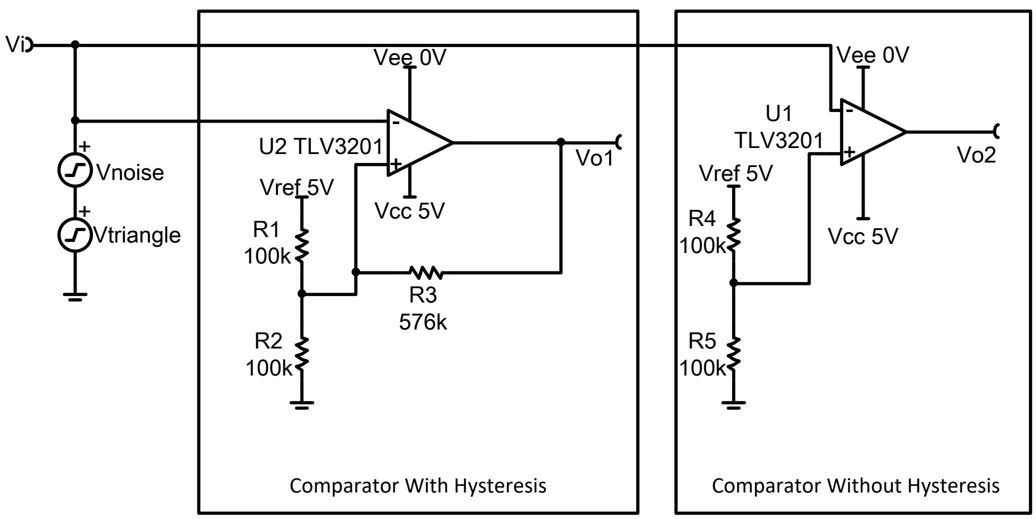
Design Goals

Input		Output		Supply		
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}	V_{ref}
0V	5V	0V	5V	5V	0V	5V

V_L (Lower Threshold)	V_H (Upper Threshold)	$V_H – V_L$
2.3V	2.7V	0.4V

Design Description

Comparators are used to compare two different signal levels and create an output based on the input with the higher input voltage. Noise or signal variation at the comparison threshold will cause the comparator output to have multiple output transitions. Hysteresis sets upper- and lower-threshold voltages to eliminate the multiple transitions caused by noise.



Design Notes

1. Use a comparator with low quiescent current to reduce power consumption.
2. The accuracy of the hysteresis threshold voltages are related to the tolerance of the resistors used in the circuit.
3. The propagation delay is based on the specifications of the selected comparator.

Design Steps

1. Select components for the comparator with hysteresis.
    a. Select V_L, V_H, and R_1.

    $$V_L = 2.3V$$

    $$V_H = 2.7V$$

    $$R_1 = 100k\Omega \text{ (Standard Value)}$$

    b. Calculate R_2.

    $$R_2 = \frac{V_L}{V_{cc} - V_H} \times R_1 = \frac{2.3V}{5V - 2.7V} \times 100k\Omega = 100k\Omega \text{ (Standard Value)}$$

    c. Calculate R_3.

    $$R_3 = \frac{V_L}{V_H - V_L} \times R_1 = \frac{2.3V}{2.7V - 2.3V} \times 100k\Omega = 575k\Omega \approx 576k\Omega \text{ (Standard Value)}$$

    d. Verify hysteresis width.

    $$V_H - V_L = \frac{R_1 \times R_2}{(R_3 \times R_1) + (R_3 \times R_2) + (R_1 \times R_2)} \times V_{cc}$$

    $$= \frac{100k\Omega \times 100k\Omega}{(576k\Omega \times 100k\Omega) + (576k\Omega \times 100k\Omega) + (100k\Omega \times 100k\Omega)} \times 5V = 0.399V$$

2. Select components for comparator without hysteresis.
    a. Select V_{th} and R_4.

    $$V_{th} = 2.5V$$

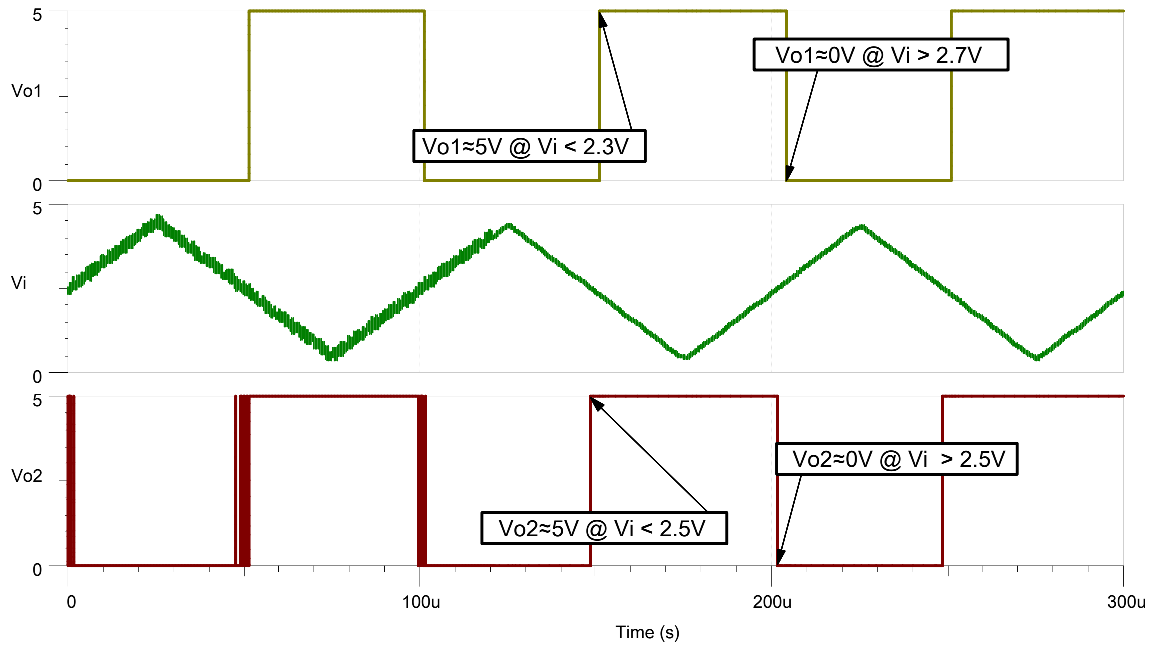
    $$R_4 = 100k\Omega \text{ (Standard Value)}$$

    b. Calculate R_5.

    $$R_5 = \frac{V_{th}}{V_{cc} - V_{th}} \times R_4 = \frac{2.5V}{5V - 2.5V} \times 100k\Omega = 100k\Omega \text{ (Standard Value)}$$

Design Simulations

Transient Simulation Results



Noise Only Present From 0s to 120µs

Zoomed in From 40µs to 110µs

Design References

Texas Instruments, SBOC515 circuit SPICE simulation file, software download

Texas Instruments, *Comparator with Hysteresis*, reference design

Design Featured Comparator

TLV3201	
V_{cc}	2.7V to 5.5V
V_{inCM}	Extends 200mV beyond either rail
V_{out}	(V_{ee}+230mV) to (V_{cc}–210mV) at 4mA
V_{os}	1mV
I_q	40µA
I_b	1pA
UGBW	—
SR	—
#Channels	1 and 2
TLV3201	

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Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (February 2019) to Revision B (October 2024) — **Page**

- Updated the format for tables, figures, and cross-references throughout the document.................................. 1

Changes from Revision * (February 2018) to Revision A (February 2019) — **Page**

- Downscale the title and changed title role to 'Amplifiers'. Added links to circuit cookbook landing page and SPICE simulation file.. 1