

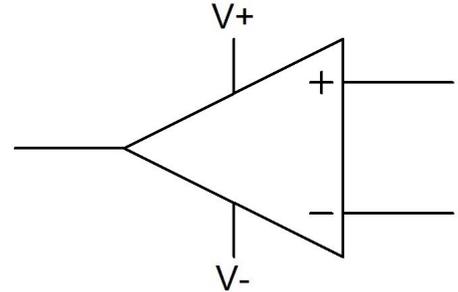
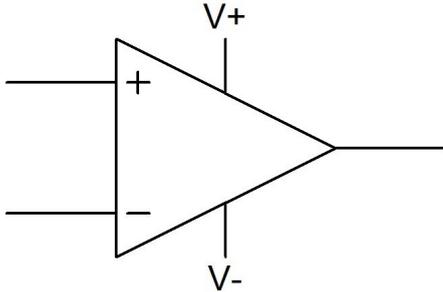
Using Op Amps as Comparators

by James Bryant

**View the notes as well as the slides
of this PowerPoint presentation**

Using Op Amps as Comparators

**Diagrams of op amps & comparators
look very similar**

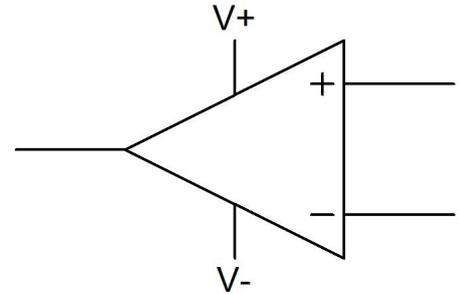
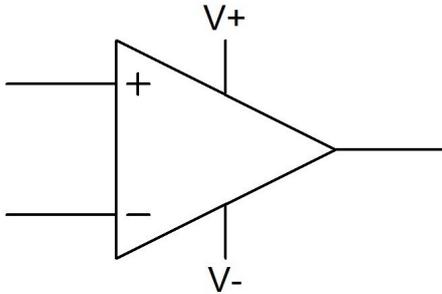


But a comparator gives a logic output indicating
the relative potentials on its two inputs

An op amp amplifies the differential voltage
between its two inputs – and is designed always
to be used in closed-loop applications

Using Op Amps as Comparators

When considering using
an op amp as a comparator
remember Mr. Punch's
advice
to those about to marry

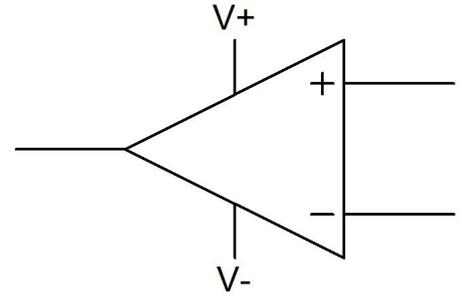
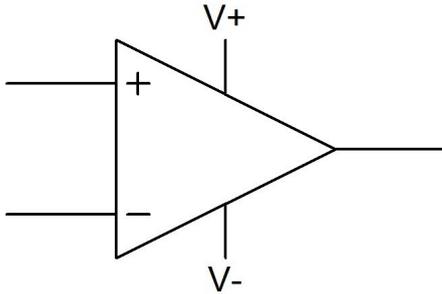


DON'T!

The rest of this presentation consists of advice for those who have not taken this advice

Using Op Amps as comparators

Why use an op amp as a comparator?



Convenience

(use the "spare" device in a quad)

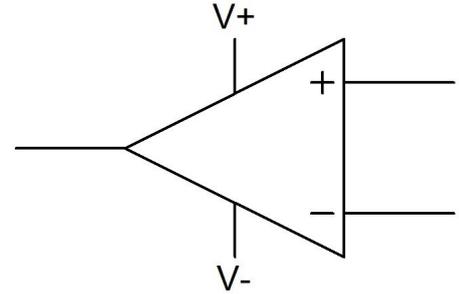
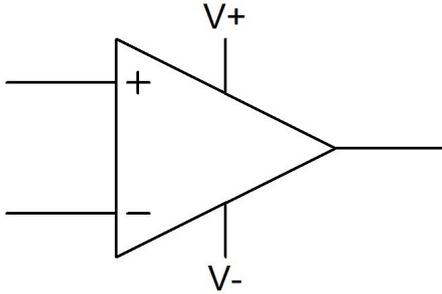
Economy

Low I_b

Low V_{os}

Using Op Amps as comparators

Why NOT use an op amp as a comparator?



Speed

(saturation means that op amps are slower)

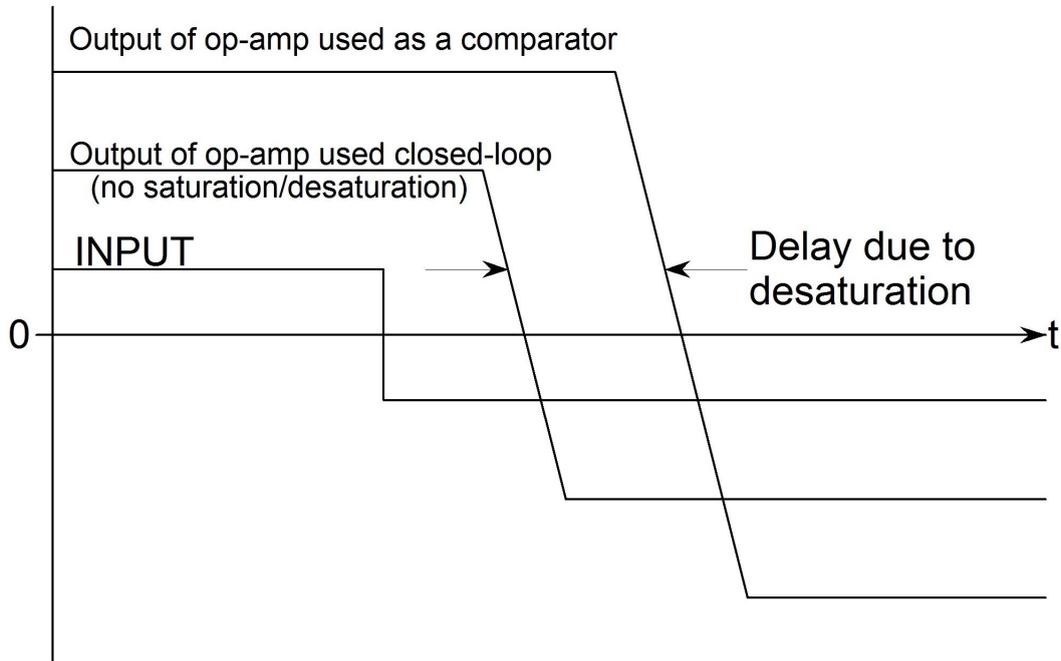
Inconvenient input structures

Inconvenient logic structures

Stability / hysteresis

Using Op Amps as Comparators

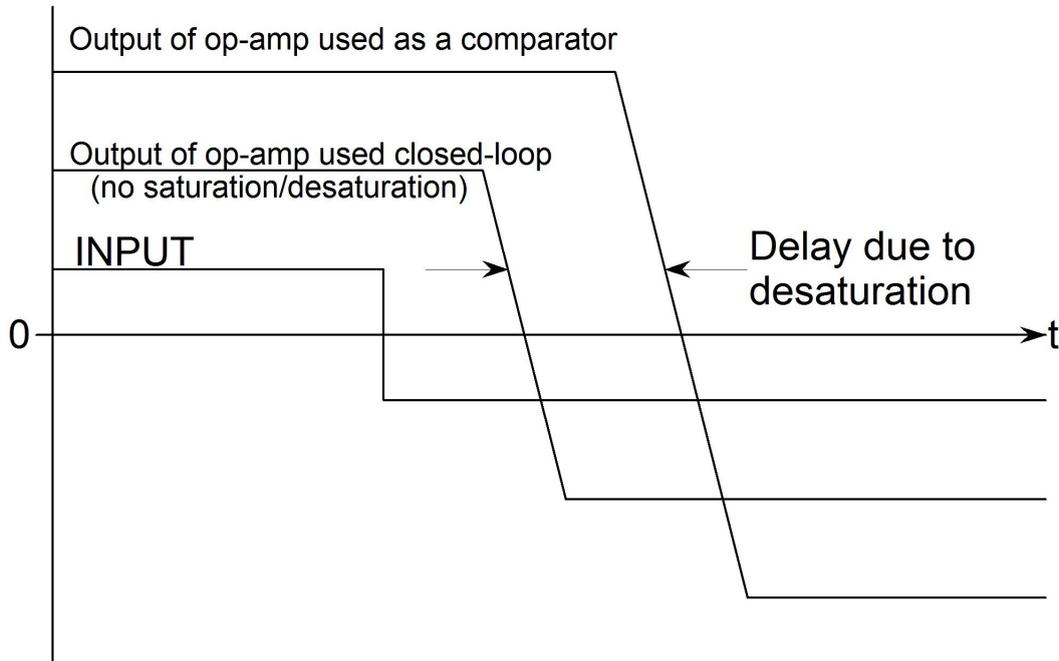
SATURATION makes an op amp used as a comparator slower than the same amplifier used closed-loop



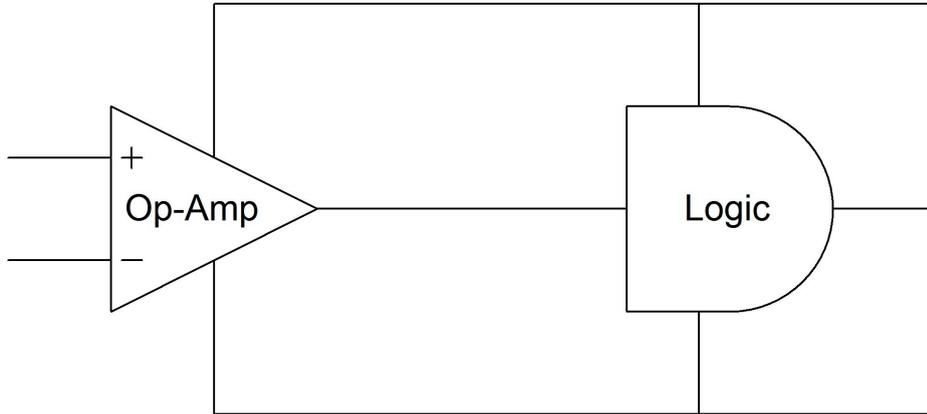
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DESATURATION is slow – and is rarely characterized on the data sheet

Testing for yourself is unreliable since batch-batch variations may be large



Using Op Amps as Comparators

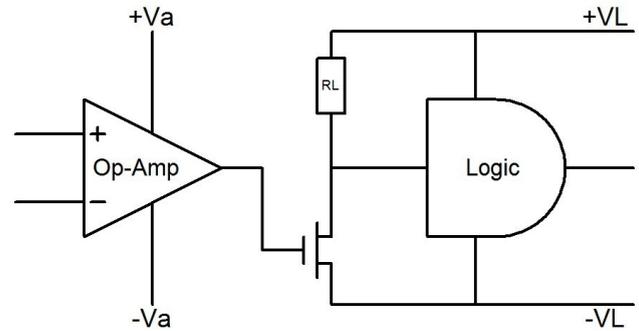
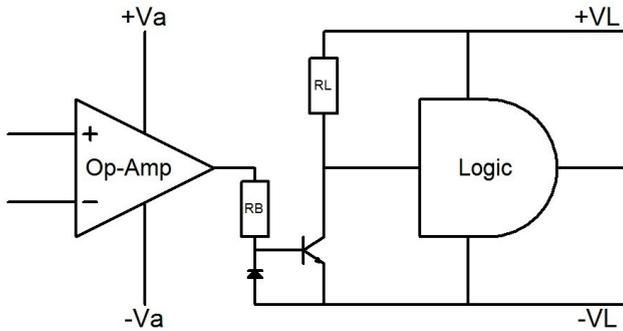


A rail-to-rail op amp will drive CMOS or TTL logic using the same supply.

If the devices have different supplies interface circuitry is necessary.

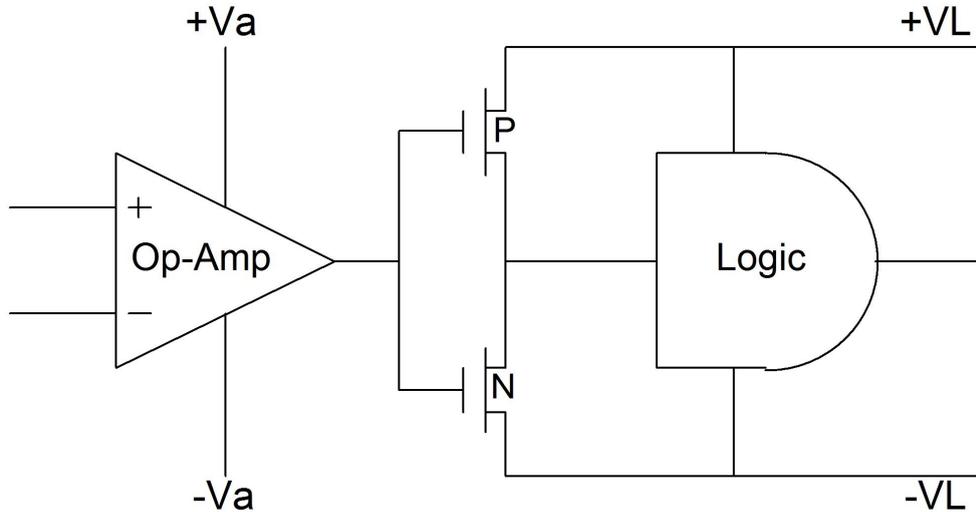
Using Op Amps as Comparators

The simplest interfaces between comparators and logic using different supplies are inverters using a single transistor or MOSFET



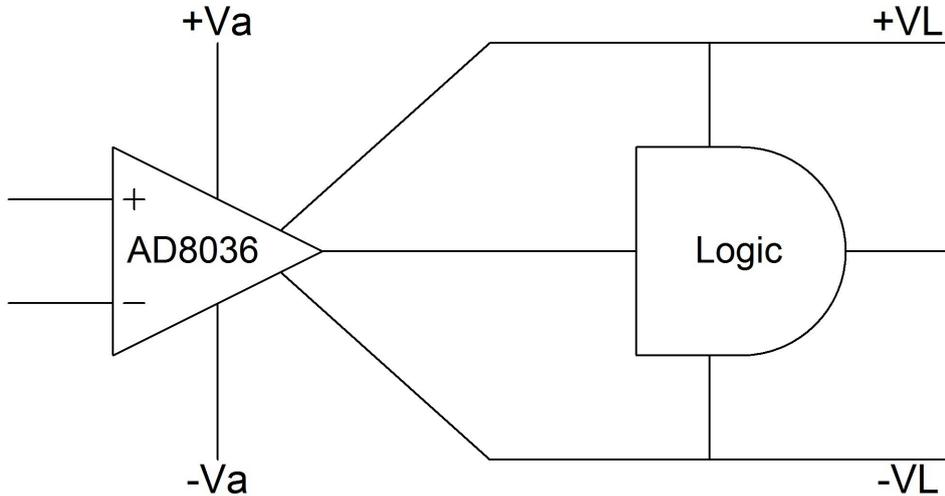
Using Op Amps as Comparators

An inverter using complementary MOSFETs (P-channel and N-channel) draws no static current



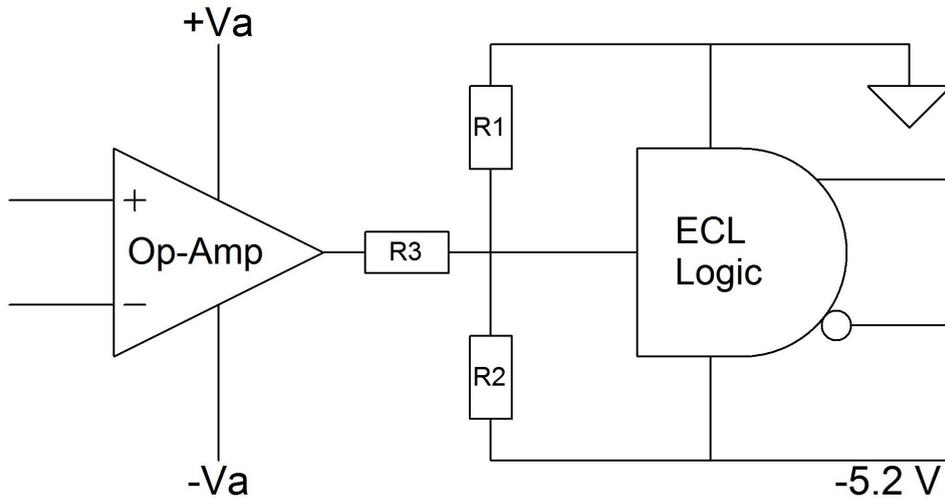
Using Op Amps as Comparators

A clamp amplifier such as the AD8036 can have its output swing limited to the logic supplies without the use of any additional components



Using Op Amps as Comparators

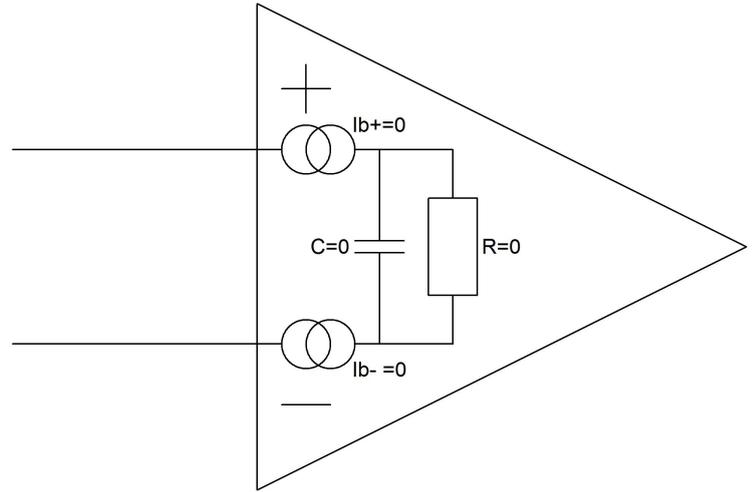
An ECL interface requires just three resistors



Using Op Amps as Comparators

An ideal op amp
has infinite Z_{in} and
zero bias current

Real life is not so pretty



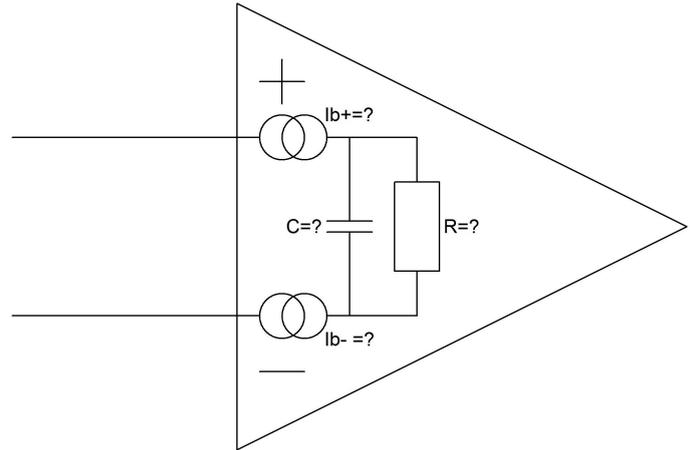
Using Op Amps as Comparators

An ideal op amp
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Real life is not so pretty

Except with current-feedback op amps
(which have asymmetric input structures
and should not be used as comparators)
it is reasonable to assume that C and I_b
are small and R is large

But designs must consider the effects of
the actual values



Using Op Amps as Comparators

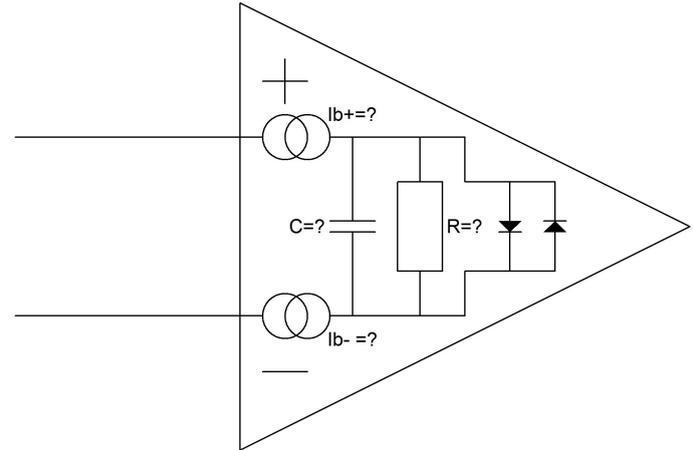
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But designs must consider the effects of
the actual values

And of any nonlinearities



Using Op Amps as Comparators

RTFDS

(Read The Friendly Data Sheet)

Determine if nonlinearities in your op amp's input will affect its operation as a comparator

LOOK FOR

Low values of absolute maximum differential input voltage

Graphs of bias current vs. differential or common-mode input voltage (and especially graphs with discontinuities or gross nonlinearities)

Any other input specification or graph which may indicate nonlinearities

**WILL YOUR PROPOSED APPLICATION WORK
WITH A COMPARATOR WHICH BEHAVES IN THIS WAY?**

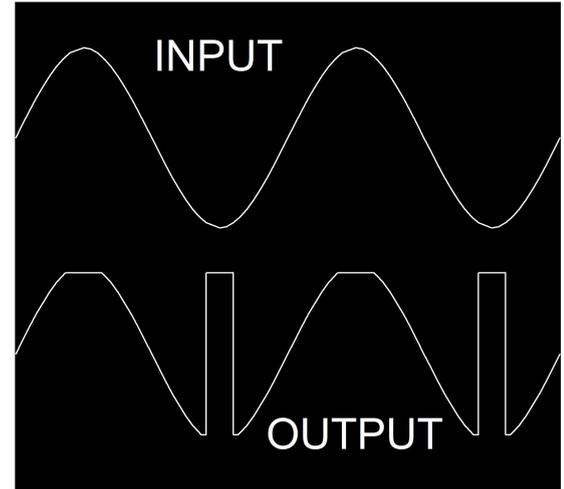
Using Op Amps as Comparators

PHASE INVERSION

Some older types of FET op amp and even a few bipolar types suffered from a phenomenon called **phase inversion** or **phase reversal**

If the common-mode voltage went outside certain limits the inverting and non-inverting inputs became interchanged

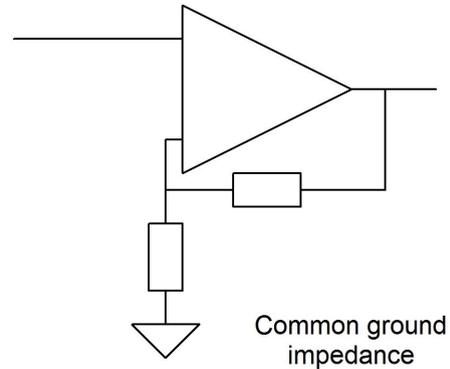
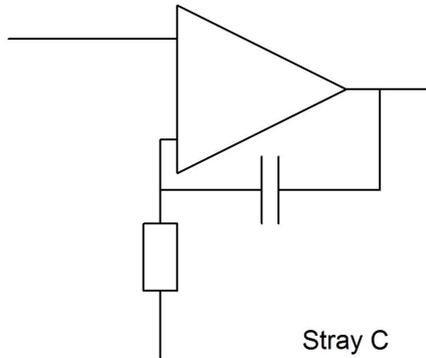
This effect would be devastating in a comparator and it is important to ensure that any op amp used as a comparator is either free from phase inversion or that it will never be used with a common-mode voltage which causes phase inversion



Using Op Amps as Comparators

INSTABILITY

Op amps used as comparators are working at their full open-loop gain and may suffer instability or latch-up due to feedback from stray capacity or due to common ground impedances

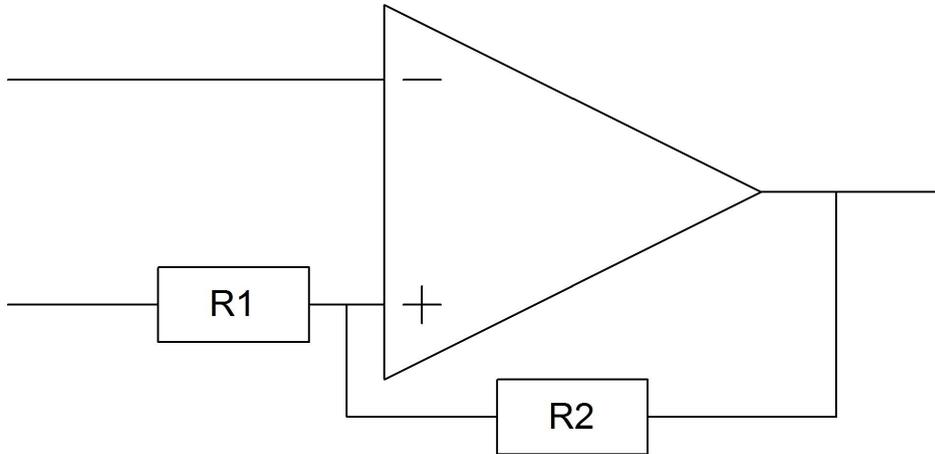


Using Op Amps as Comparators

HYSTERESIS

Using controlled positive feedback to produce hysteresis
can reduce the risk of oscillation

The amount of hysteresis is predictable and is controlled
by the ratio of the positive feedback resistors



Output Swing: V_s

Hysteresis

$$\frac{V_s (R_1 + R_2)}{R_1}$$

**Signal applied to R_1 must come from a source
impedance which is much lower than R_1**

Using Op Amps as Comparators

HYSTERESIS

Calculation of thresholds when the reference is not midway between the supplies

Comparator output voltages are V_p & V_n

Reference voltage is V_r

Positive threshold is $\frac{R_2 V_r + R_1 V_p}{R_1 + R_2}$

Negative threshold is $\frac{R_2 V_r + R_1 V_n}{R_1 + R_2}$

Using Op Amps as Comparators

CONCLUSION

**OP AMPS MAY BE USED AS COMPARATORS
BUT BE CAREFUL!**

Read The Friendly Data Sheet (RTFDS)

Calculate the effects of non-ideal parameters

Experiment

Always interpret your results a little pessimistically