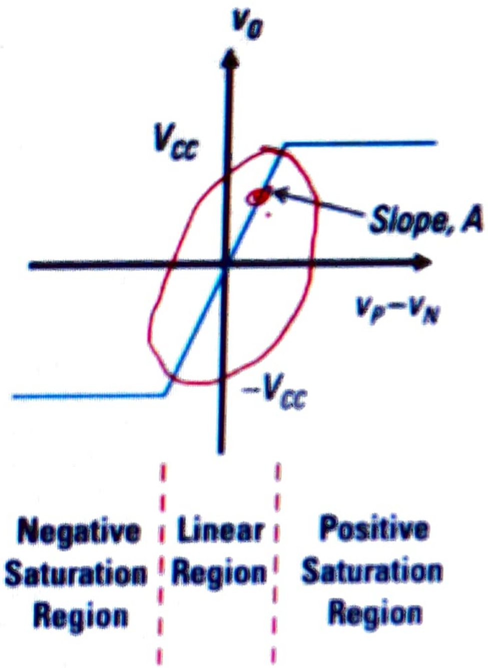
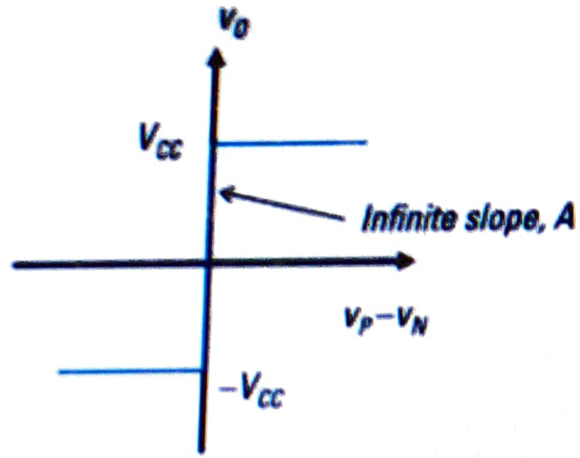
Transfer characteristics of op-amp





Transfer Characteristic of an Ideal Op Amp

Negative saturated region: $v_O = -V_{CC}$

Linear active region: $v_O = A_v\left(v_P - v_N\right)$

Positive saturated region: $v_O = +V_{CC}$

Raise hand

Turn on captions

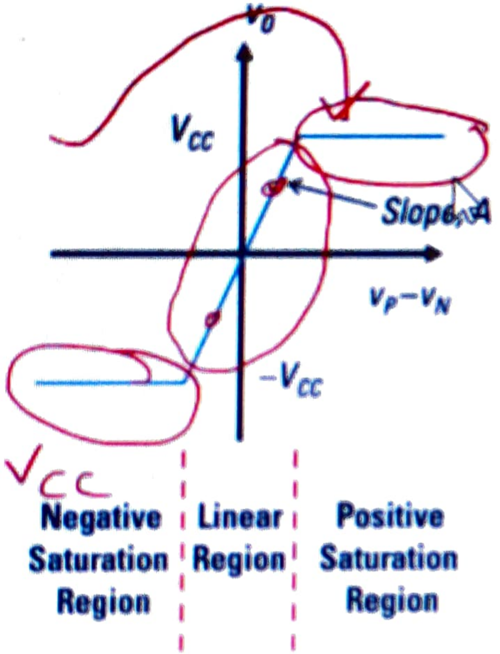
Transfer characteristics of op-amp

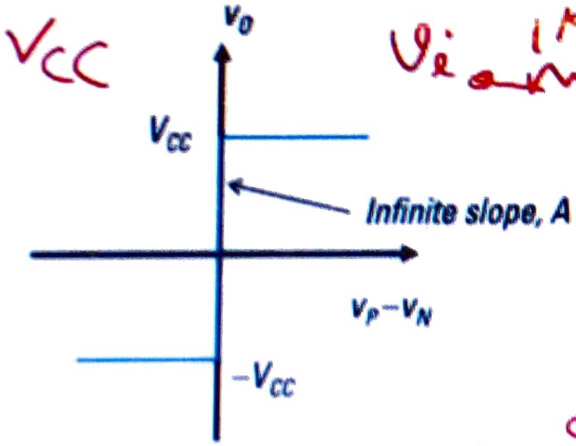
$v_0 > V_{CC}$

if $v_o > V_{CC}$

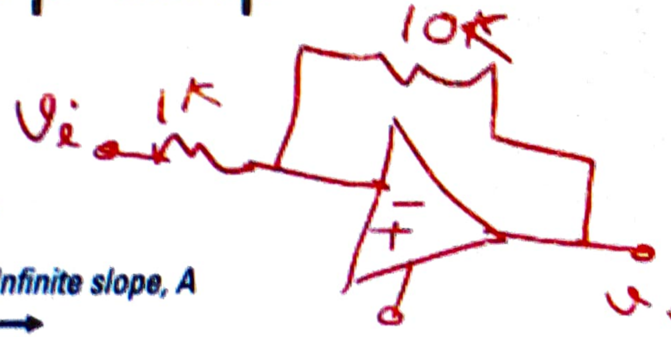
Saturation $\simeq -V_{CC}$

$+V_{CC}$





Transfer Characteristic of an Ideal Op Amp



$\pm 15V$

gain $= 10$

$v_o = 10\, v_i$

if $v_i = 1\,V$

$v_o = -10\,V < V_{CC}$ $+15$

$v_i = 2\,V$

$v_o =$

Negative saturated region: $v_O = -V_{CC}$

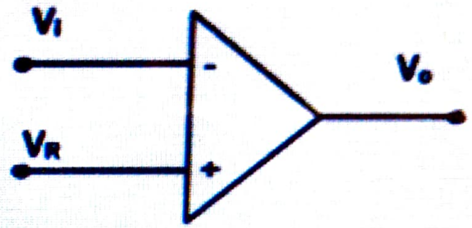
Linear active region: $v_O = A_v(v_P - v_N)$

Positive saturated region: $v_O = +V_{CC}$

Saturation

Non-linear operation of op-amps

- Op-amp in open loop (no feedback)
  - Operates in non-linear fashion
- Open loop applications of op-amp
  - Comparators
  - Detectors
  - Converters etc.



Saturation

Non-linear operation of op-amps

NO feedback

- Op-amp in open loop (no feedback)
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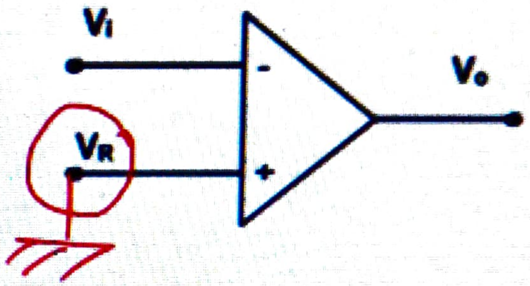


Comparator $v_R = 0$

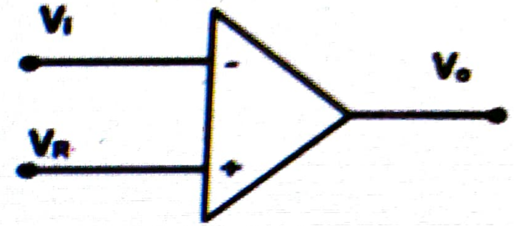
$v_R = \pm 1$

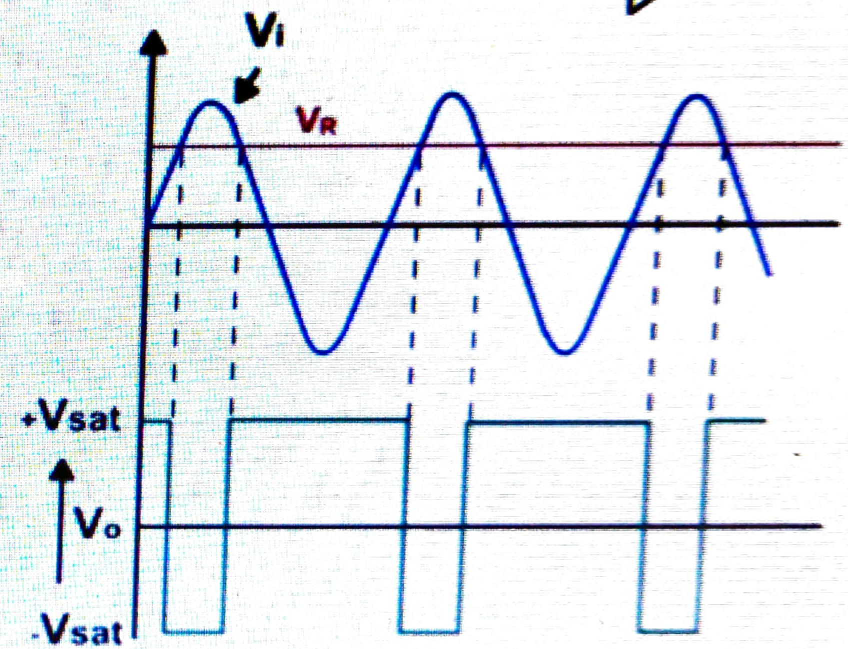
Inverting Comparator

- An analog comparator has
  - **Two inputs**
    - A constant reference voltage V_R and other is a
    - Time varying signal v_i
  - **One output v_O**

$$v_o = -V_{sat} \qquad if\ v_i > V_R$$

$$v_o = +V_{sat} \qquad if\ v_i < V_R$$





Vsat 14.8V Vcc ≤15

Inverting Comparator

$v^+ > v^- \Rightarrow V_o = +V_{sat}$

- An analog comparator has
  - **Two inputs**
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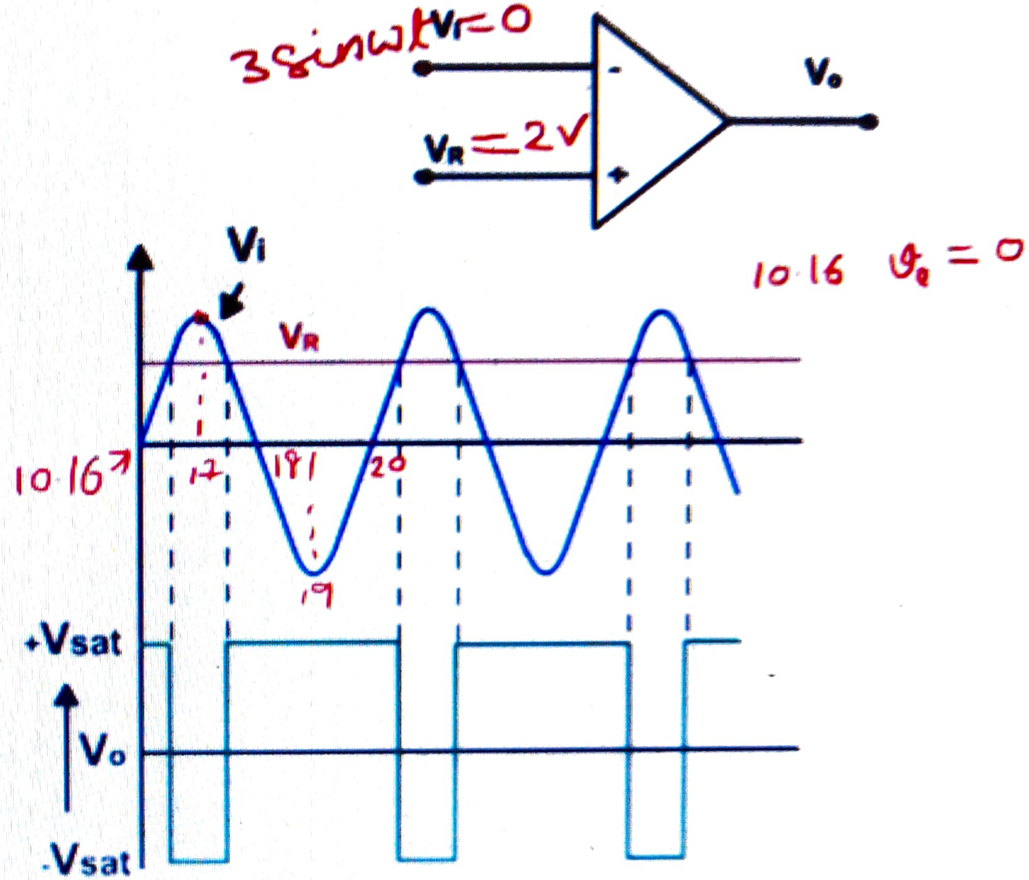


$v_i = V_R$ ← theory

$V^+ > V^- \Rightarrow V_0 = +V_{sat}$

Vcc

V_{sat} 14.8V ← 15

Inverting Comparator

10.16 → $v_i = 0 \Rightarrow V^+ > V^- \Rightarrow v_0 = +V_{sat}$

10.17 → $v_i = 3V \Rightarrow V^- > V^+ \Rightarrow v_0 = -V_{sat}$

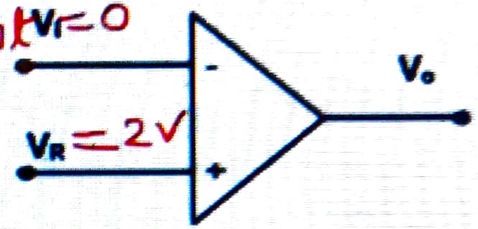
10.18 → $v_i = 0 \Rightarrow V^+ > V^- \Rightarrow v_0 = +V_{sat}$

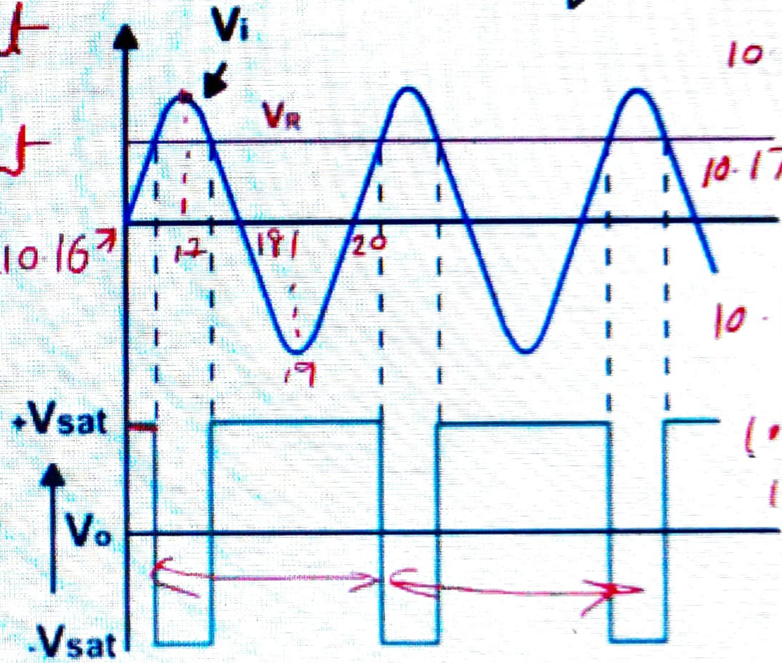
10.19 → $v_i = -3 \Rightarrow 2 > -3 \Rightarrow v_0 = +V_{sat}$

10.20 → $v_i = 0 \Rightarrow 2 > 0 \Rightarrow v_0 = +V_{sat}$

PW -ve ≠ +ve PW

+ve = -ve PW





10.16 $v_i = 0$

10.17 $v_i = 3 \sin 90 = 3V$

10.18 $v_i = 0$

10.19 $= -3$

10.20 $= 0$

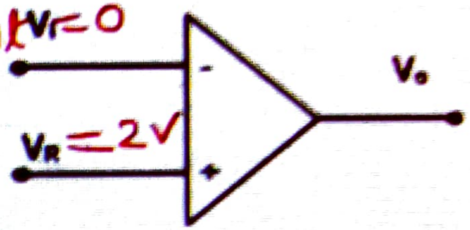
V_{cc}

V_{sat} 14.8V ← 15

$\boxed{v_i = V_R}$ ← theory ✓

$v^+ > v^- \Rightarrow V_0 = +V_{sat}$

Inverting Comparator



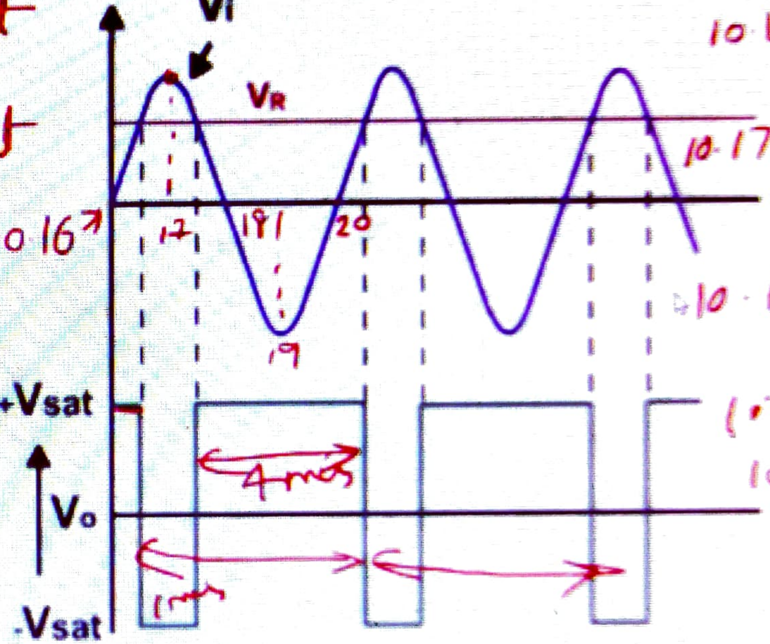
10.16 → $v_i = 0 \Rightarrow v^+ > v^- \Rightarrow v_0 = +V_{sat}$

10.17 → $v_i = 3V \Rightarrow v^- > v^+ \Rightarrow v_0 = -V_{sat}$

10.18 → $v_i = 0 \Rightarrow v^+ > v^- \Rightarrow v_0 = +V_{sat}$

10.19 → $v_i = -3 \Rightarrow 2 > -3 \Rightarrow v_0 = +V_{sat}$ 10.16

10.20 → $v_i = 0 \Rightarrow 2 > 0 \Rightarrow v_0 = +V_{sat}$



10.16 $v_i = 0$

10.17 $v_i = 3\sin 90$ $= 3V$

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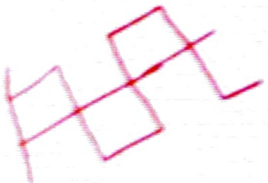
10.20 $= 0$



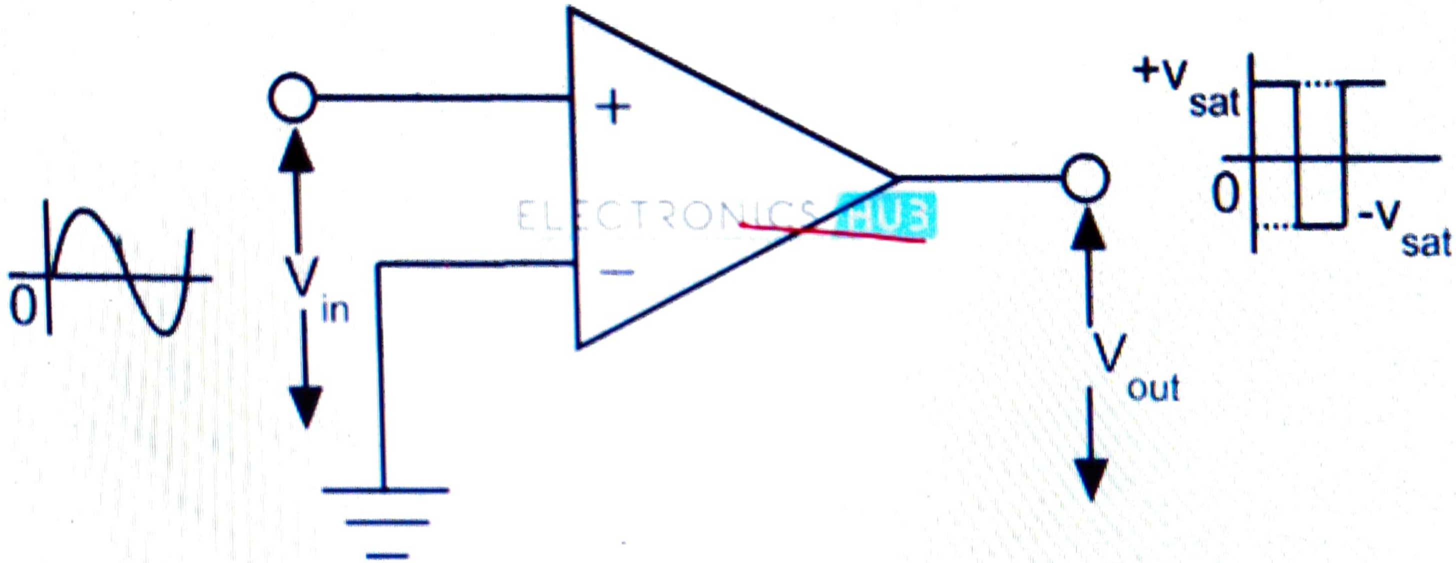
PW

−ve

+ve PW

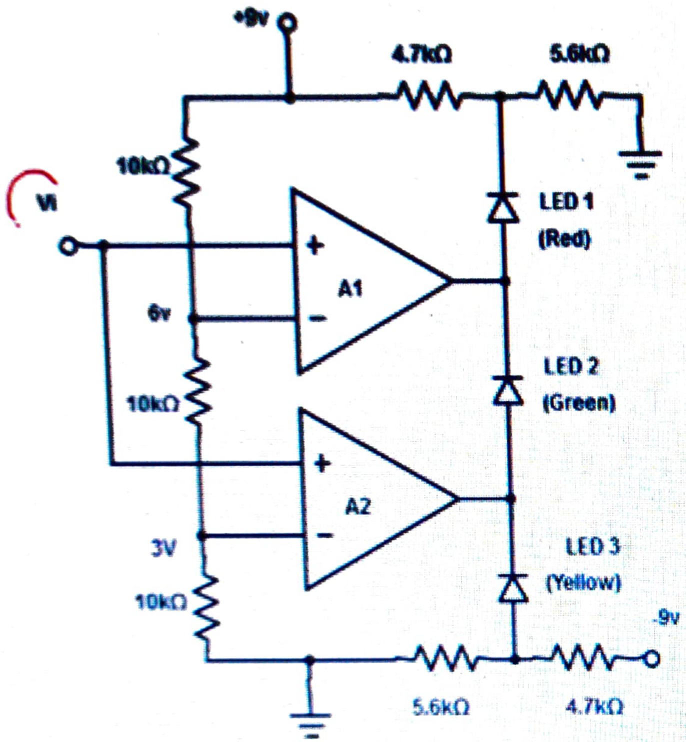
+ve = −ve PW

Zero crossing detector



Raise hand
Turn on captions

Three level comparator with LED



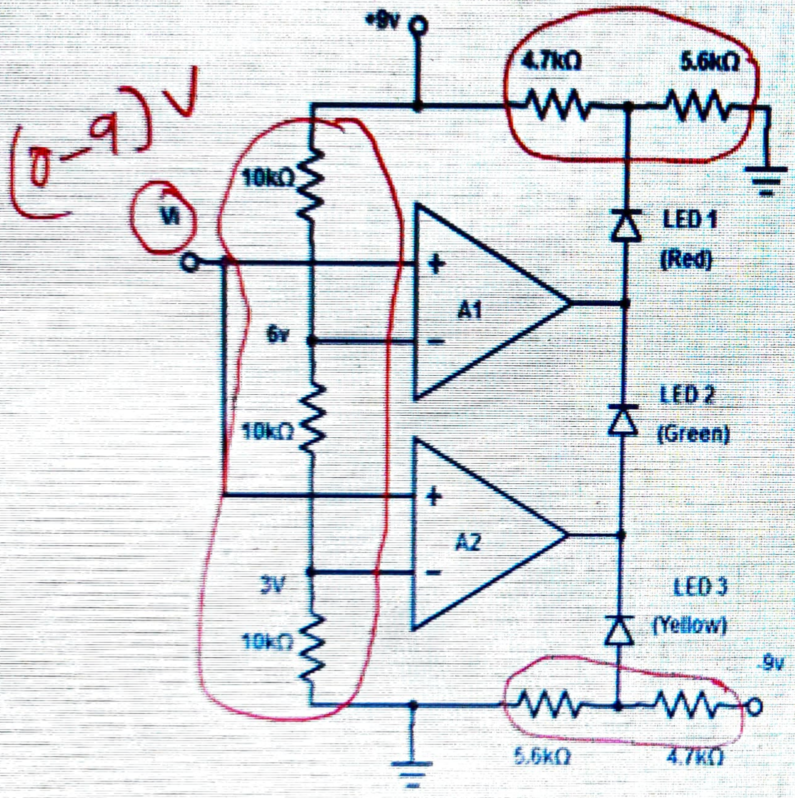
Input (V)	LED 3	LED 2	LED 1
< 3			
3 < vi < 6			
> 6			

Dr. E Paul Braineard

Raise hand

Turn on captions

Three level comparator with LED



Input (V)	LED 3	LED 2	LED 1
< 3			
3 < vi < 6			
> 6			

Raise hand

Turn on captio

$V_{R1} = \frac{20}{30} \times 9 = 6V$

Three level comparator with LED

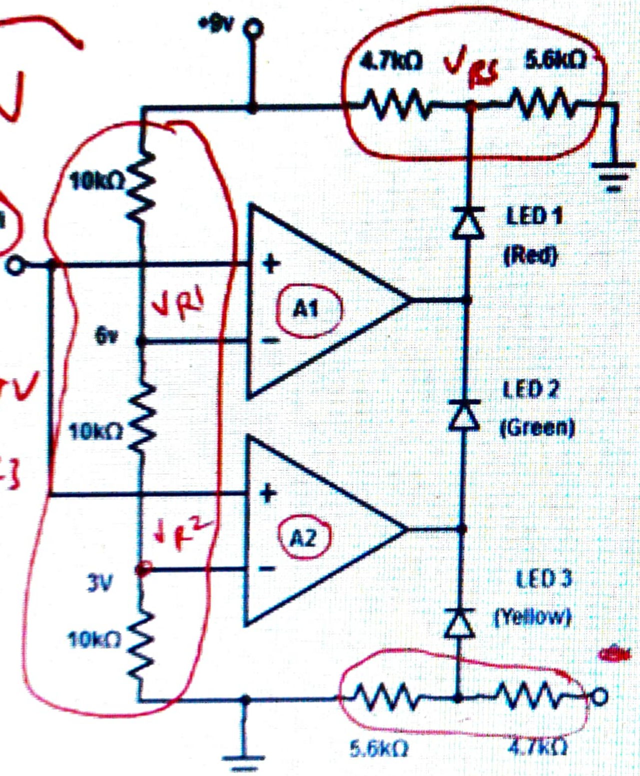
$V_{R2} = 3V$

9V

R_1, V_{R1}, R_2, R_3

(0–9)V

$V_{R1} = \frac{R_2+R_3}{R_1+R_2+R_3} 9V$



Input (V)	LED 3	LED 2	LED 1
< 3			
3 < vi < 6			
> 6			

$V_{R1} = \frac{20}{30} \times 9 = 6V$

Three level comparator with LED

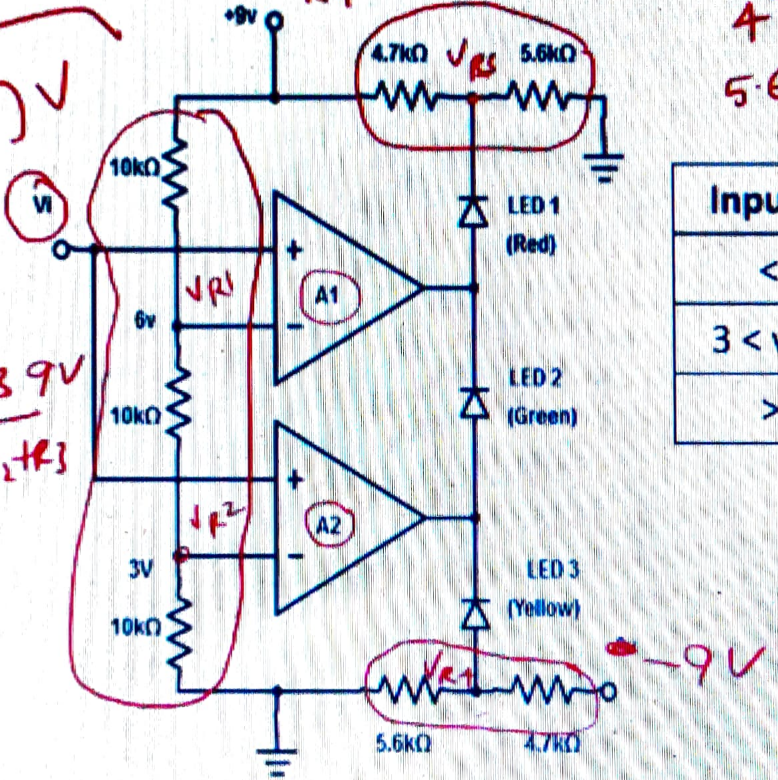
$V_{R2} = 3V$ $V_{R3} = 4.9V$

$V_{R4} =$

9V

R_1, $V_{R'}$, R_2, R_3 (0-9)V

$V_{R1} = \frac{R_2+R_3}{R_1+R_2+R_3} 9V$



9V, 4.7, 5.6

$V_{R3} = \frac{5.6}{4.7+5.6} \times 9 = 4.89V$

Input (V)	LED 3	LED 2	LED 1
< 3			
3 < vi < 6			
> 6			

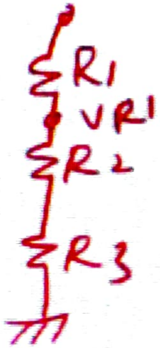
$V_{R1} = \frac{20}{30} \times 9 = 6V$

Three level comparator with LED

$V_{R2} = 3V$ $V_{R3} = 4.8V$

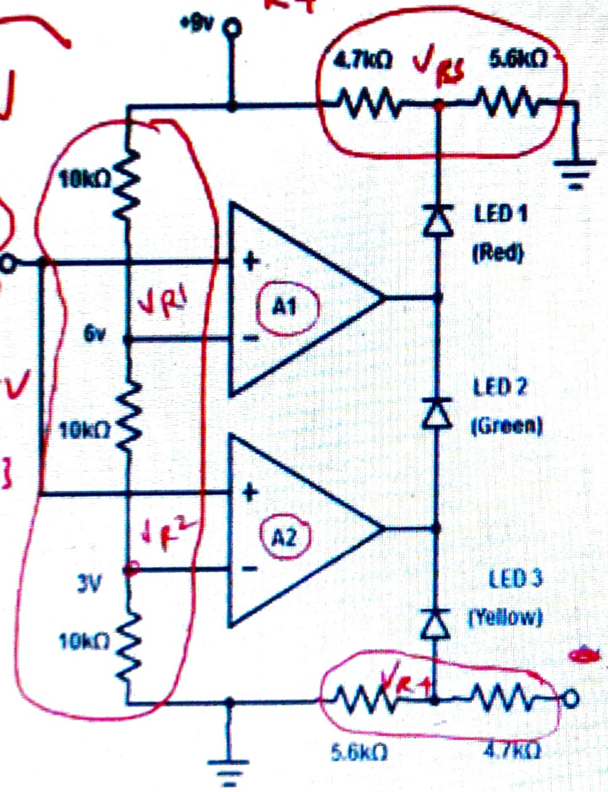
$V_{R4} = -4.89V$

9V



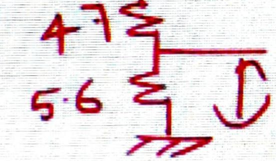
(0-9)V

2V



-9V

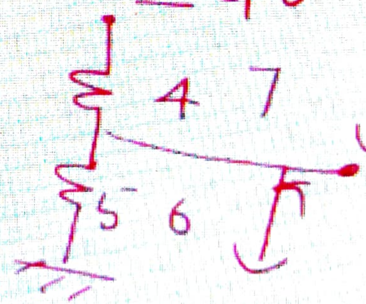
$V_{R1} = \frac{R_2+R_3}{R_1+R_2+R_3} 9V$



$V_{R3} = \frac{5.6}{4.7+5.6} \times 9 = 4.89V$

Input (V)	LED 3	LED 2	LED 1
< 3			
3 < vi < 6			
> 6			

-9V



$V_{R4} = \frac{5.6 \times -9}{4.7+5.6}$

Three level comparator with LED

$V_{R1} = \frac{20}{30} \times 9 = 6V$

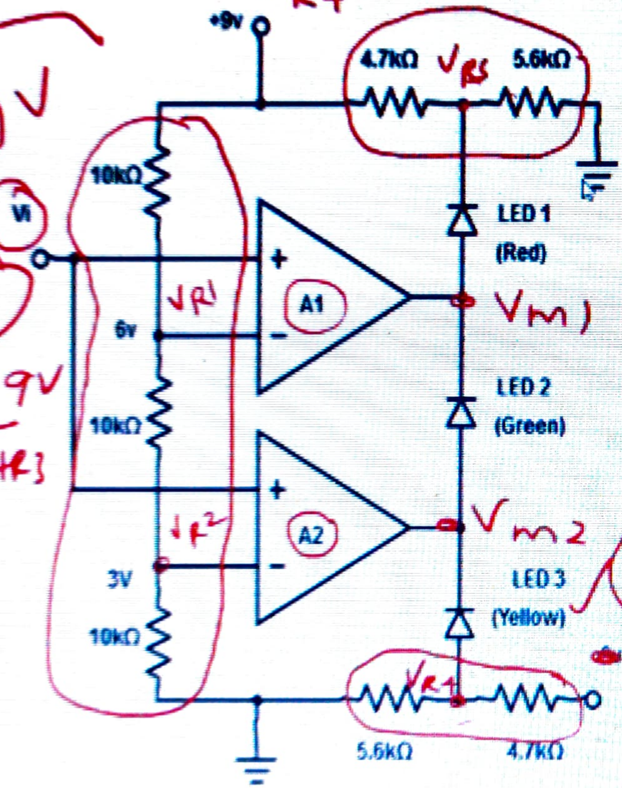
$V_{R2} = 3V$

$V_{R3} = 4.89V$

$V_{R4} = -4.89V$

$(0-9)V$

$V_{R1} = \frac{R_2+R_3}{R_1+R_2+R_3} 9V$



$V_{R3} = \frac{5.6}{4.7+5.6} \times 9 = 4.89V$

Input (V)	LED 3	LED 2	LED 1
< 3			
3 < vi < 6			
> 6			

$V_{R4} > V_{M2}$

$V_{R4} = \frac{5.6}{4.7+5.6} \times -9$