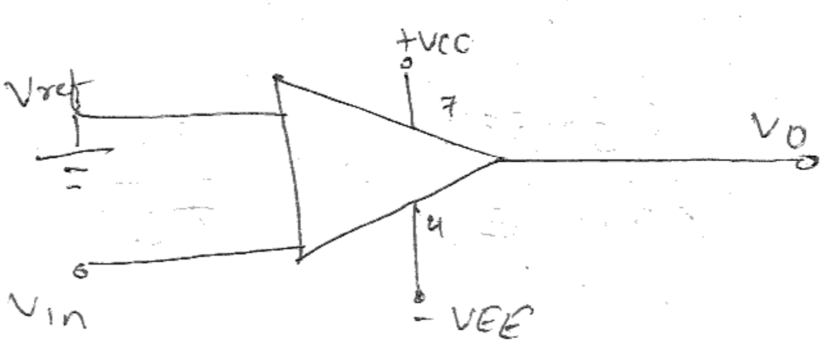
12/7/11

COMPARATOR

A comparator is a circuit which compares a signal voltage applied at one input of the op-amp with a known voltage at the other input and produce either a higher or low voltage in the output depending on which i/p is high.

Types of comparator

1. Non-Inverting comparator :-



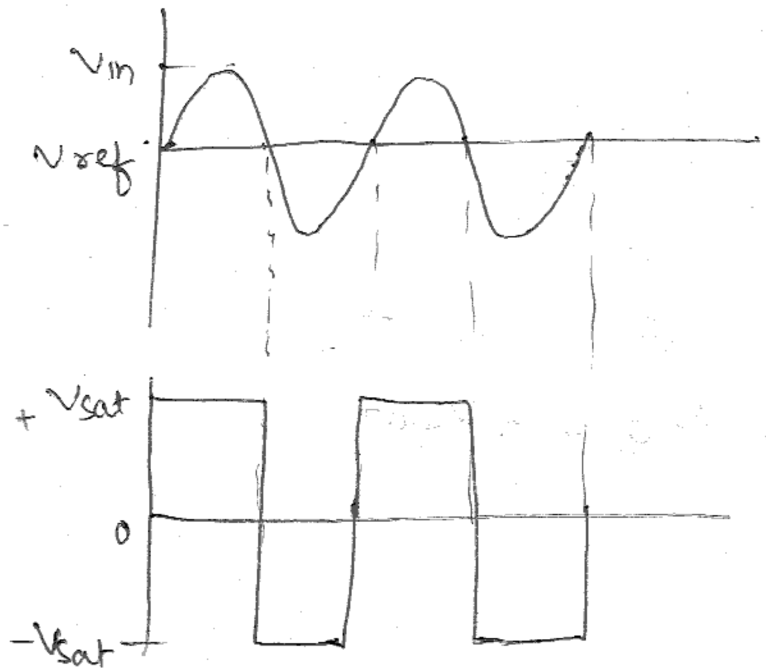
$V_{in} > V_{ref} \Rightarrow O/P + V_{sat} = +V_{CC}$

$V_{in} < V_{ref} \Rightarrow O/P - V_{sat} = -V_{EE}$

Thus the two possible output levels of the comparator are $+V_{sat}$ or $-V_{sat}$ indicating whether the i/p voltage is greater than or less than the ref voltage. Such type of comparator in which operation is at

Saturation level is called Saturating level of Comparator.

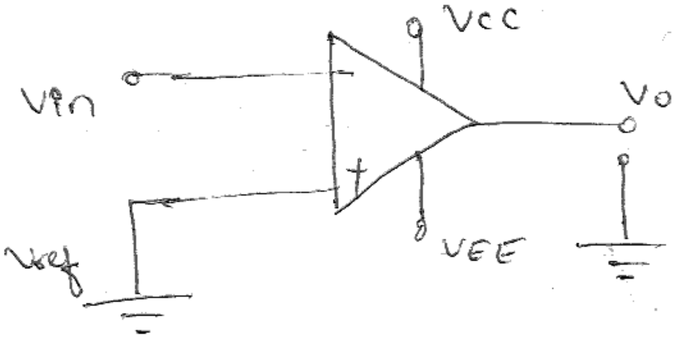
<u>Output waveform</u>



The op-amp differential voltage gain A_{OL} is very Large. ± V_{sat} i.e the Saturation voltage levels of op-amp are mentioned and hence ~~by Vsat~~ by knowing V_{sat} and differential voltage gain we Can determine the minimum, input voltage level required to Saturate is

$$\boxed{V_{in(min)} = \frac{V_{sat}}{A_{OL}}}$$

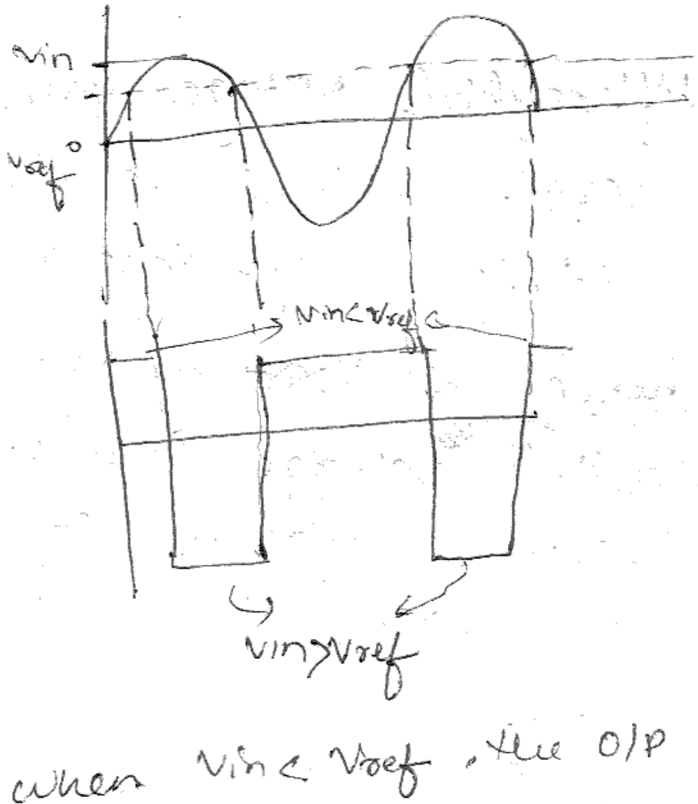
2. Inverting Comparator



$V_{in} < V_{ref} \Rightarrow V_o = +V_{sat}$

$V_{in} > V_{ref} \Rightarrow V_o = -V_{sat}$

O/P waveform.

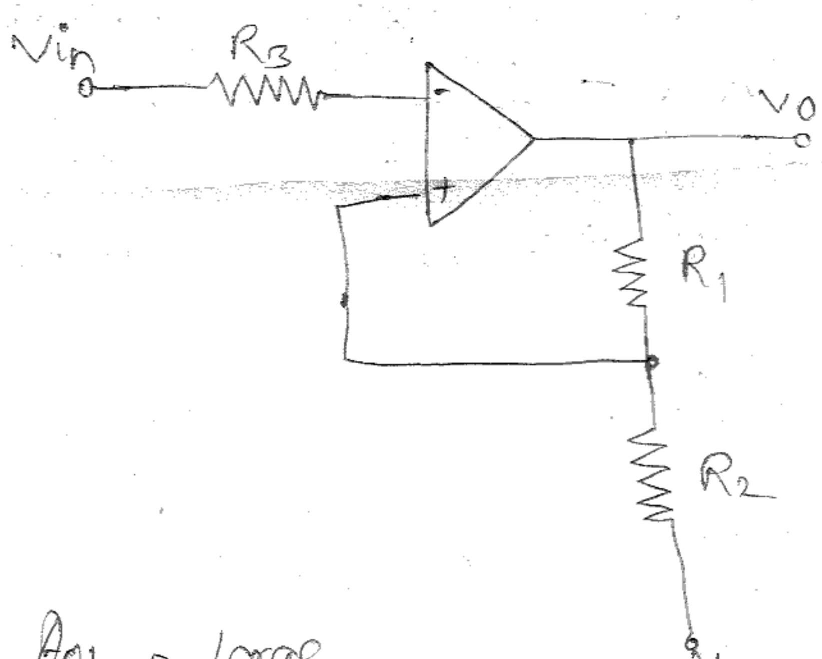


So when $V_{in} < V_{ref}$, the O/P voltage V_o is at $+V_{sat}$ because the voltage at the inverting I/P is less than at the non-inverting i/P and when $V_{in} > V_{ref}$, the O/P non investing i/p becames -ve witer respect to the investing i/p and so Vo goes to -Vsat.

Applications of comparator :-

1. zero crossing detector,
2. Time Marker generator.
3. Phase detector.
4. window detector.
5. pulse generator.
6. level detector.

Schmitt Trigger (Regenerative comparator)



AOL = large
↓
Noise → distubs the circuit
to remove noise we provide Positive feedback.

$-\beta A_{OL} = 1$ which gives $A_{vF} \to \alpha$

For ar As A_{OL} can't be maintained at constant value, so

$$A_{OL} > 1$$

This gives rise to a phenomenon called "hysteresis".

hysteresis width $= V_{UT} - V_{LT}$

V_{UT} → upper threshold voltage.
V_{LT} → Lower " " .

$$V_H = V_{UT} - V_{LT}$$

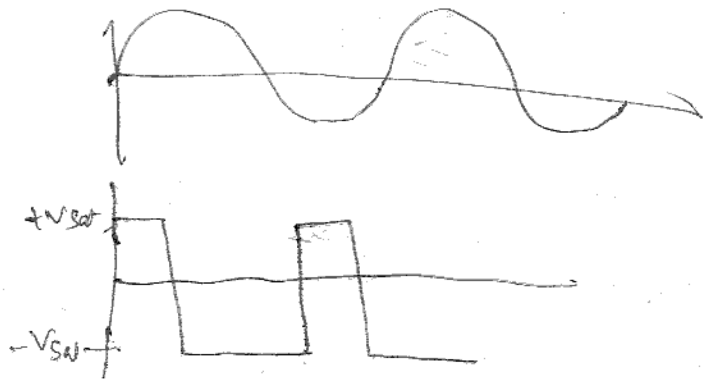
$$\boxed{V_{UT} = V_{ref} + \frac{R_2}{R_1+R_2}(V_{sat} - V_{ref})}$$

As long as $V_i < V_{UT}$, the V_o remains at $+V_{sat}$

$$\boxed{V_{LT} = V_{ref} - \frac{R_2}{R_1+R_2}(V_{sat} + V_{ref})}$$

When $V_i > V_{UT}$, the V_o switches to $-V_{sat}$

O/P waveform



Hysteresis ~~width~~ $V_H = V_{UT} - V_{LT}$

$$= \cancel{V_{ref}} + \frac{R_2}{R_1+R_2}(V_{sat} - V_{ref}) -$$

$$\cancel{V_{ref}} + \frac{R_2}{R_1+R_2}(V_{sat} + V_{ref})$$

$$= \frac{R_2}{R_1+R_2}\left[V_{sat} - \cancel{V_{ref}} + V_{sat} + \cancel{V_{ref}}\right]$$

$$V_H = \frac{2R_2}{R_1+R_2} \cdot V_{sat}.$$

If PK-PK input signal V_i is smaller than V_H, then the Schmitt trigger circuit having a threshold voltage could never reset itself.

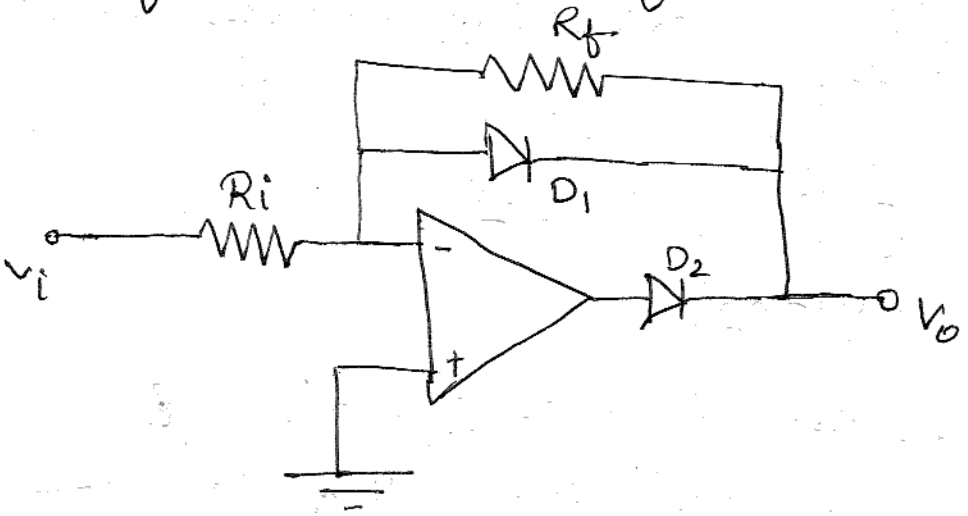
If V_{ref} is choosen at 0V then

$$V_{UT} = -V_{LT} = +\frac{R_2}{R_1+R_2} \cdot V_{sat}$$

PRECISION RECTIFIERS :-

→ Half wave Rectifier
→ Full wave Rectifier

Half wave Rectifier



Case 1 :-

→ V_i is positive i.e $V_i > 0$

D_1 – ON → conducts

D_2 – OFF → Reverse bias

V_o → zero

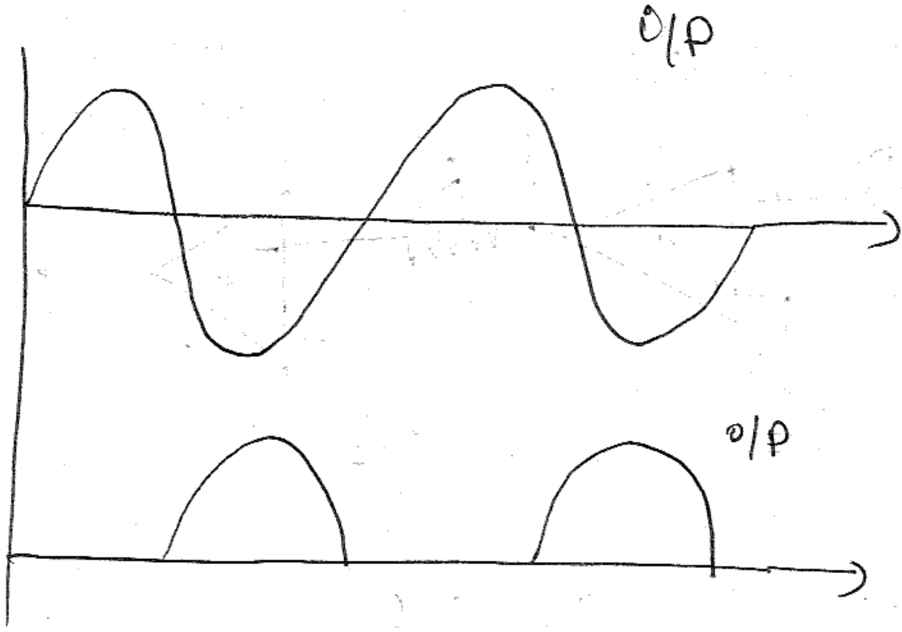
Case 2 :-

→ V_i is −ve i.e. $V_i < 0$

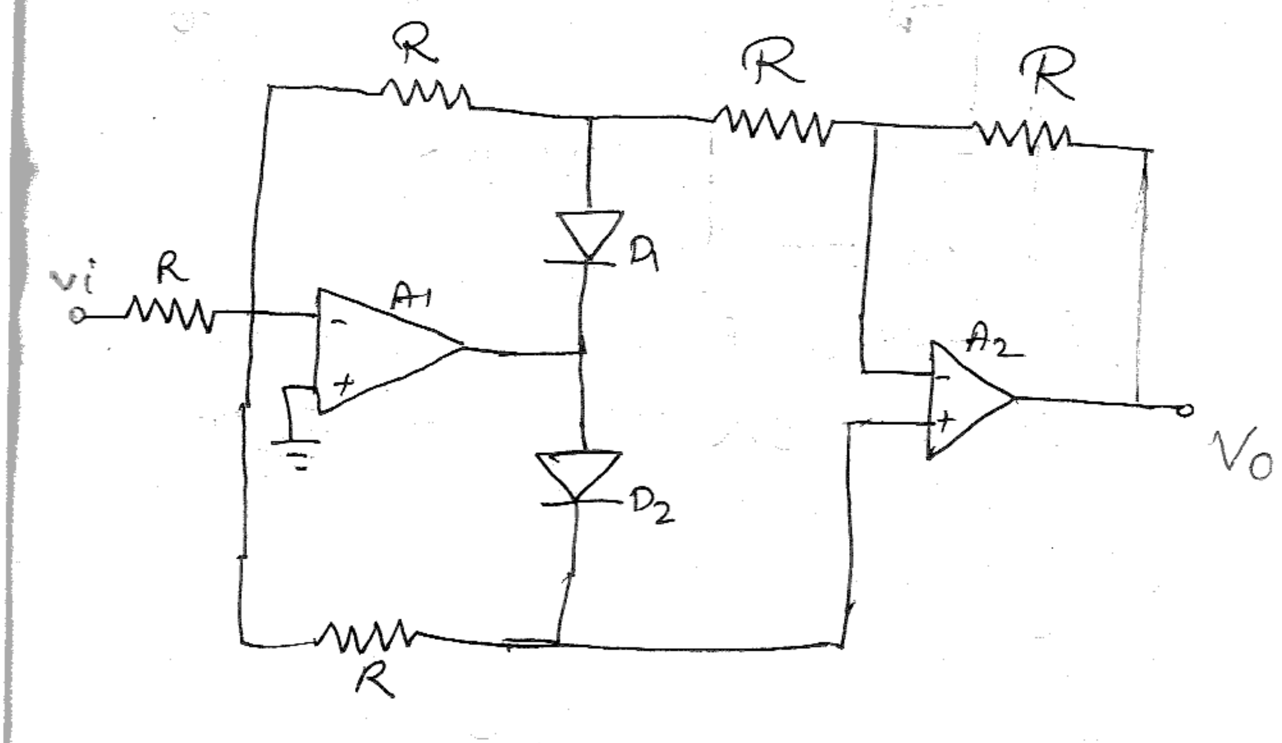
D_1 – OFF

D_2 – ON

Case 2:



FULL WAVE RECTIFIER

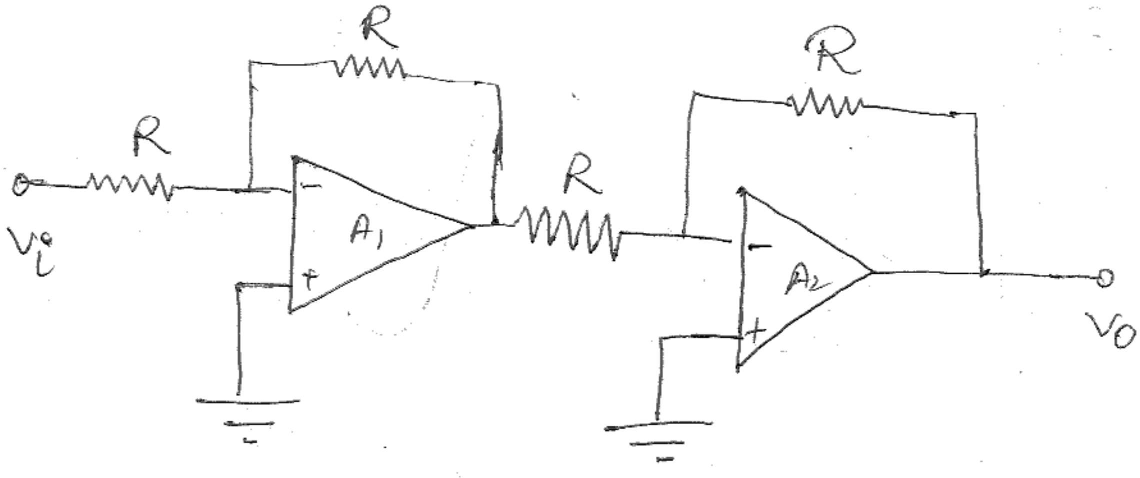


Case 1:-

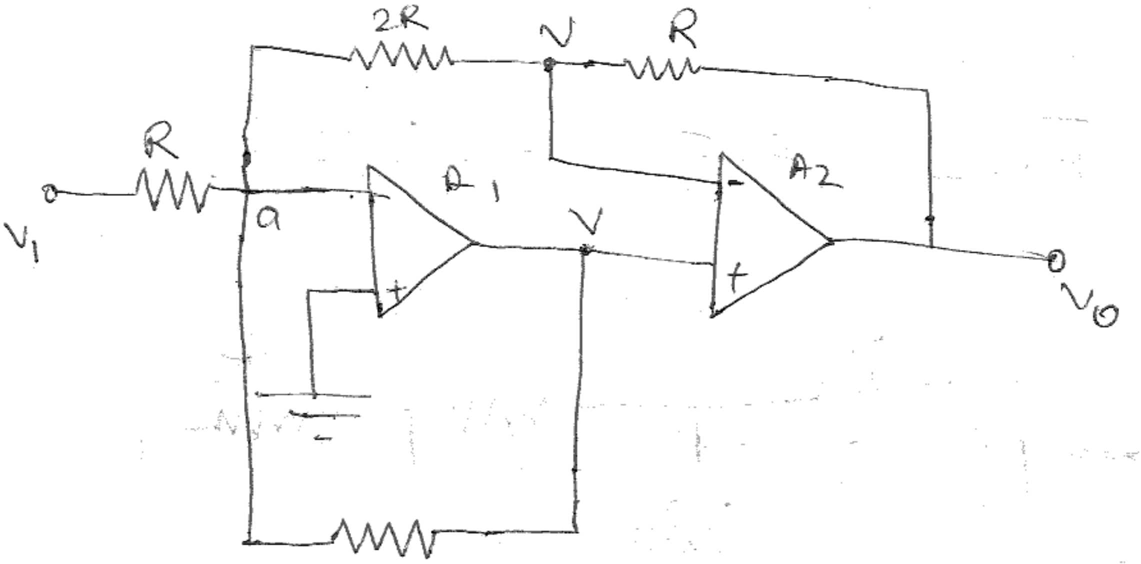
$V_i > 0$

D_1 - ON, D_2 - OFF

A_1 & A_2 acts as inverter.



Case (ii) $v_i < 0$



$D_1 \rightarrow$ OFF

$D_2 \rightarrow$ ON

using node 'a'

$$\frac{v_i}{R} + \frac{v}{2R} + \frac{v}{R} = 0$$

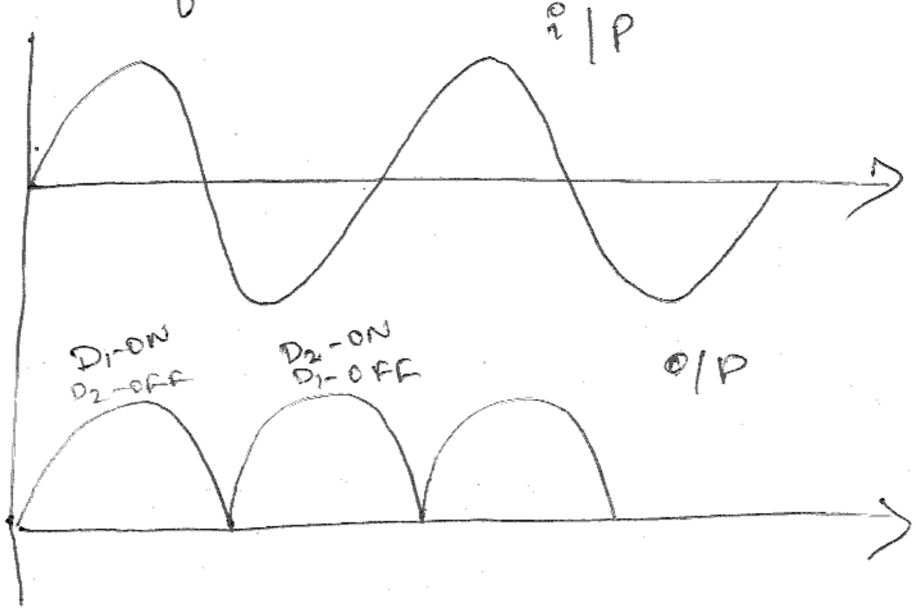
$$v = -\frac{2}{3} v_i$$

$$V_o = \text{Gain}\,(v_i)$$

$$= \left(1+\frac{R_f}{R_i}\right)\left(-\frac{2}{3}V_i\right)$$

$$V_o = -\frac{2}{3}\left(1+\frac{R_f}{R_i}\right)V_i$$

waveform



Monostable Multivibrator

$$V_o = V_{fi} + (V_{in} - V_{fin})\, e^{-t/RC}$$

$V_{fi} = -V_{sat}$ $\quad$ $V_{in} = V_D$

$V_o = -\beta V_{sat}$

$$\Rightarrow -\beta V_{sat} = -V_{sat} + (V_D + V_{sat})\, e^{-T/RC}.$$

$$\Rightarrow V_{sat} - \beta V_{sat} = (V_D + V_{sat})\, e^{-T/RC}$$

$$V_{sat}(1-\beta) = (V_D + V_{sat})\, e^{-T/RC}$$

$$\frac{V_{sat}(1-\beta)}{V_D + V_{sat}} = e^{-T/RC}$$

$$\Rightarrow \frac{(1-\beta)}{\left(1 + \frac{V_D}{V_{sat}}\right)} = e^{-T/RC}$$

$$\ln\left(\frac{1-\beta}{1 + \frac{V_D}{V_{sat}}}\right) = -T/RC$$

$$RC \ln\left(\frac{1-\beta}{1 + \frac{V_D}{V_{sat}}}\right) = -T$$

$$T = RC \ln\left(\frac{1 + \frac{V_D}{V_{sat}}}{1-\beta}\right)$$

Application

- Pulse detection.