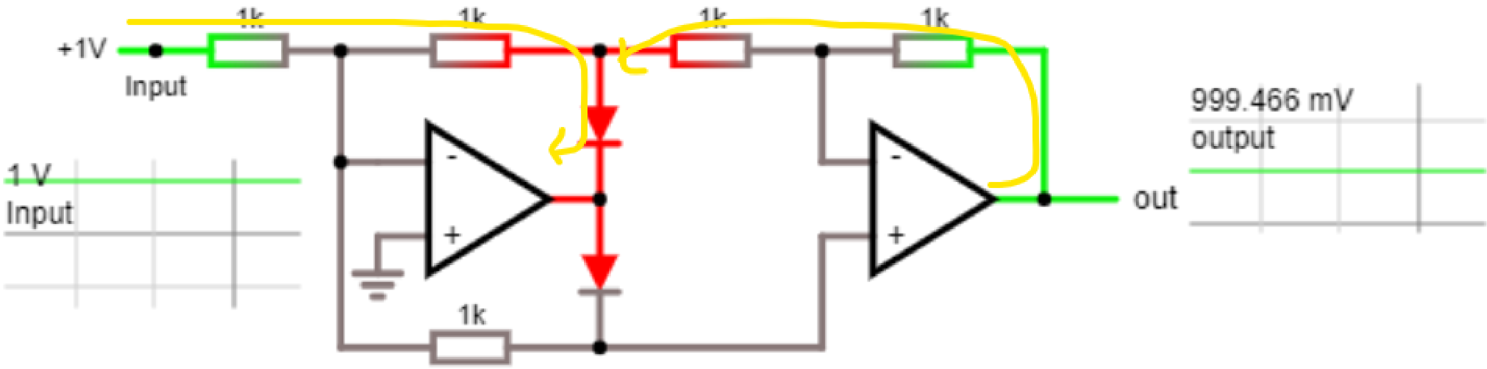
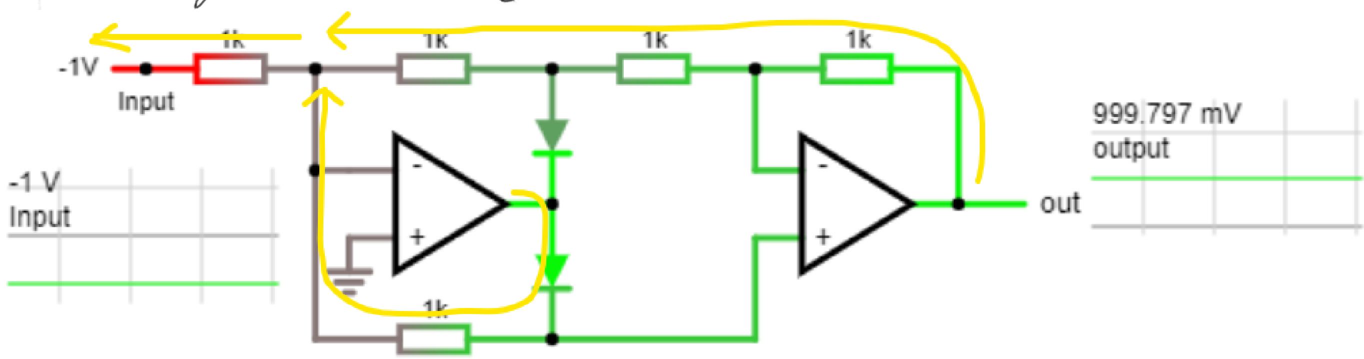
# ① Precision Rectifier

## a) Operation.

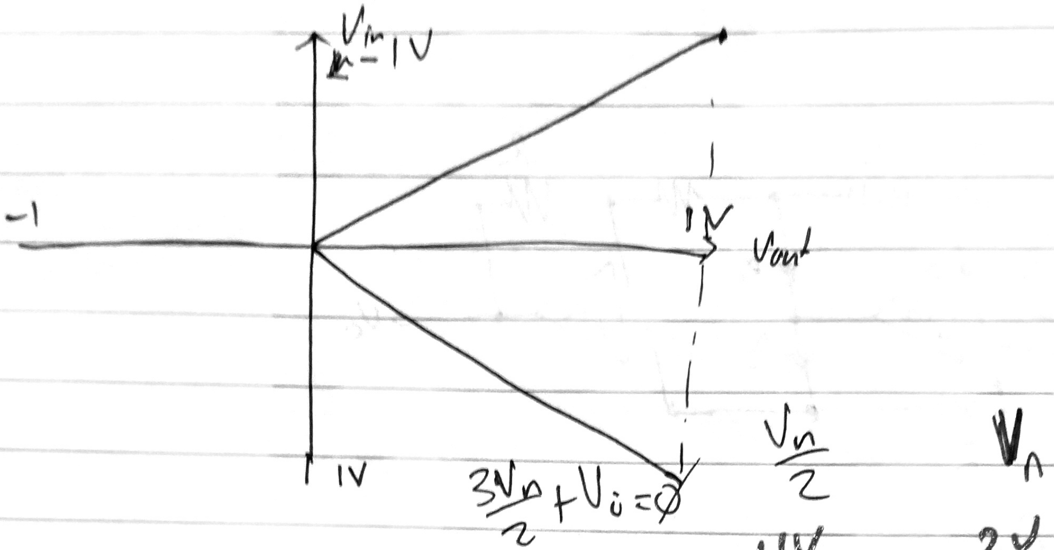



For a positive voltage, due to the virtual short of the input terminals of each op amp the only conduction path is 'into' the output of $OP_1$ (or the ØV at node 1 ie diode direction) with current flowing from each branch into $OP_1$. With that node being at $-V_{in}$, the required voltage at $OP_2$ out is $= V_{in}$.



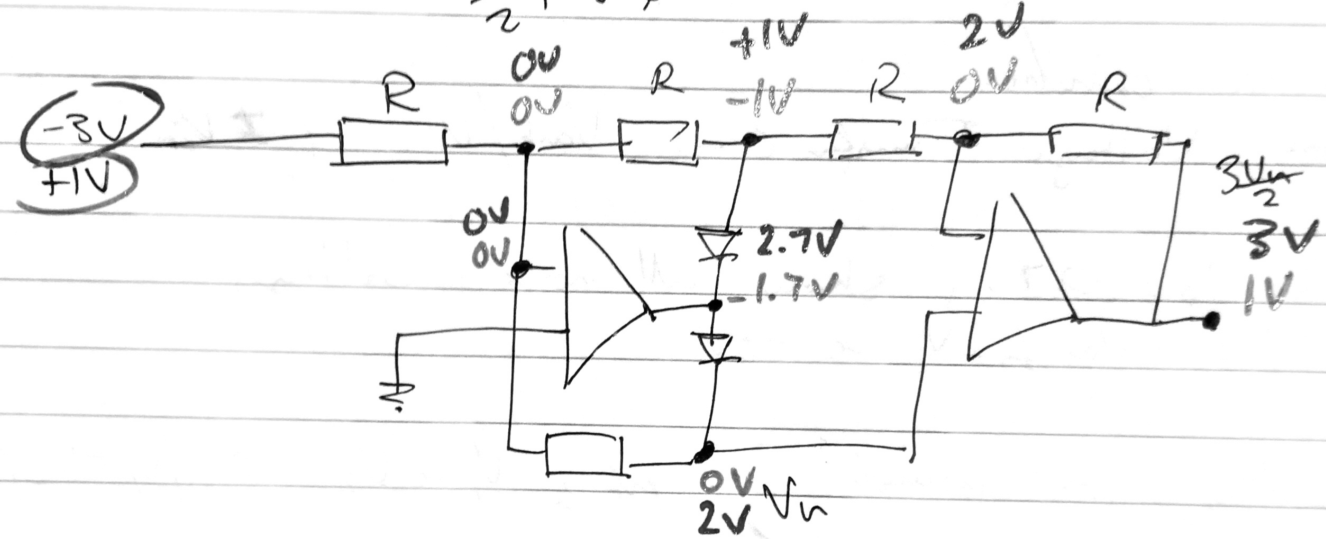

For −ve $V_{in}$ (the virtual short still remains) the conduct path is along the top branch and from the output of $Op_2$ to node 1, due to the reverse bias of $D_1$ not conducting. The voltage at bottom node ie inverting i/p of $Op_2$ are virtually shorted and 0V at inverting i/p of $Op_2$ $\frac{1}{3}|V_{in}|$ is dropped across the top branch resistors necessitating ~~Op~~ $V_{out} = -V_{in}$ ie rectified.

b)



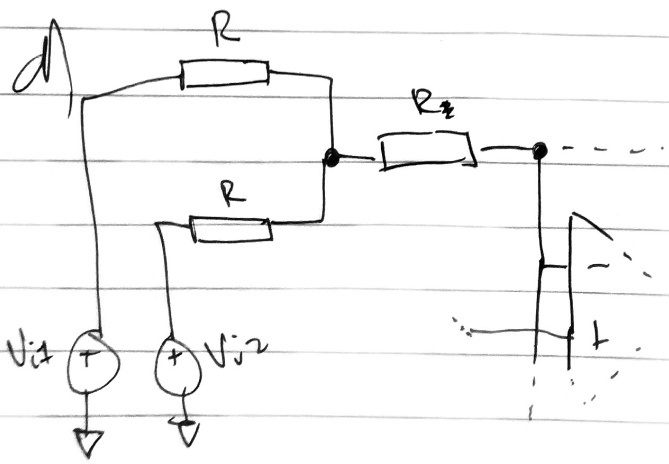
Vin
-1V
-1
1V
Vout
1V
3Vn/2 + Vi = 0
Vn/2
Vn


c)



-3V
+1V
R
0V
0V
R
+1V
-1V
R
2V
0V
R
0V
0V
2.7V
-1.7V
3Vin/2
3V
1V
0V
2V
Vn


d)



R
R
R2
Vi1
Vi2

2) This is a comparator schmitt trigger.

a) assume: $V_{O(sat)} = \pm 13V$, $R_1$, $R_2$? that give hysteresis of $\pm 1V$

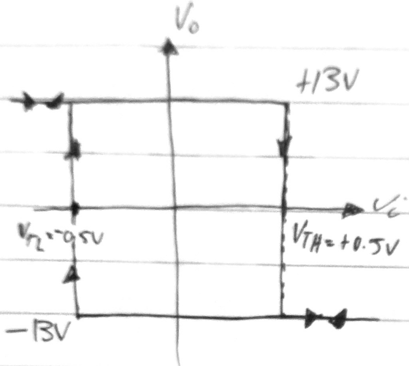
$\cancel{I = 2V_{TH} - V_{TL} = \Delta V = \Delta V_+}$ $I = V_T = 2V$ (or $\pm 0.5V$)

$$\Delta V_+ = \left(\frac{R_1}{R_1+R_2}\right) \cdot (V_{OH} - V_{OL})$$

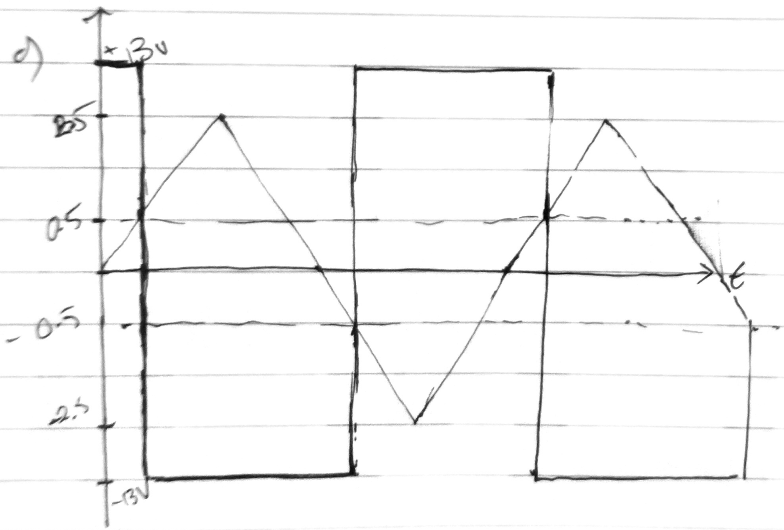
$$1 = \frac{R_1}{R_1+R_2} \cdot 26V \quad \text{ie} \quad \frac{R_1}{R_1+R_2} = \frac{1}{26}$$

$\therefore R_1 = 1K$ & $R_2 = 25K$

b)




d)




5Vpp triangle wave

3. Hysteresis is how the state of a system depends on its previous states.

In electrical circuits, hysteresis can be included to reduce/prevent unwanted, high speed switching.

Examples of this are a schmitt trigger, wiring positive feedback in -ve input

and a latching relay for higher current applications.

4. An opamp has 3 internal stages.

- The input stage, a differential configuration with moderate gain, this is key is minimising input mismatch

- The gain stage, for voltage amplification, For stability it needs roll off at ~ 1Hz So a key ~~one~~ note is the Miller Effect.
  - This accounts for the increase in equivalent capacitance.

- The output stage, this provides a low output impedance & a high current. This provide the power amplification for output. Key is protection circuitry.

5) GB = 2MHz, $V_{supp} = \pm 10V$, $V_{In-pp} = 1V$

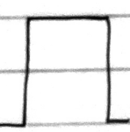
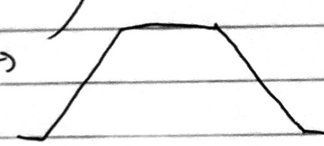
gain flat = 10x, input ⇒ 120 kHz

- calc required GB, is 2MHz enough.
- Slew Rate
- other important parameters → choosing suitable.

a) $GBP = A \times BW = 1.2MHz$

∴ as the GBP is higher than required the op-amp is suitable for this case.

b) Op amp's, being an active components, it cannot switch output values instantaneously

ie ideal ⇒  , real → 

So as the f increases the rate of this (the slew rate) will lead to distortion in the actual signal, even though the gain is preserved.

c) $A = 1V$, $\omega = 2\pi\ 120Hz$

$\therefore SR = A \cdot 2\pi f = 1 \cdot 2\pi \cdot 120$

$SR = \cancel{753.98\ V/s}$

$SR = 0.75389..\ V/\mu s$

Search for: min GBP ≥ 1.2 MHz, SR = 1V/μs

⇒ TLV342: General purpose OP Amp, GBP: 2.3 MHz, SR = 1V/μs.

(6)

$R_1 = 2k \quad R_2 = 22k \quad , V_{os} \leq 4mV \quad I_{os} \leq 30nA \quad , I_B \leq 200nA$

To minimise effect of $I_B$, $R_p \simeq R_1 // R_2$

$R_1 // R_2 = 956.5$ choose ~~1k~~ $910\Omega$ (E24)

$R_a = (R_1 // R_2 - R_p) = 46.5\Omega$, choose $47\Omega$ (E24)

Paracalmi Voltage, $V_{I\Delta} = V_{os(max)} + (R_1 // R_2) I_{os(max)}$

$= 4mV + (956.5) 30nA$

$V_{I\Delta} = 4.03mV$

So the cancel up to $4.03mV$ at non-inverting input;

$V_X = \pm 4.03mV$

$V_X = V_Y \left( \frac{R_a}{R_B + R_A} \right)$, but $V_Y \Rightarrow \pm 15V$

So to add some extra allowance for $V_X$, set to $6mV$.

$\frac{V_X}{V_Y} = \frac{R_a}{R_B + R_a} = \frac{6mV}{15V} = \frac{1}{2500}$ ~~$R_B = 1875 R_A$~~

$R_B \approx 2500 R_A$ ~~$R_B = 28125k$ E24 $\Rightarrow 91k\Omega$~~

$R_B = 117,500\ \Omega \Rightarrow 120k\Omega$ (E24)

To preserve linearity as $R_C$ varies in the nulling voltages.

$R_C << R_B$

So choose a common potentiometer value

$5k\Omega \to 10k\Omega$

Final: $R_p = 910\Omega$, $R_A = 47\Omega$, $R_B = 120k\Omega$, $R_C = 5k\Omega \to 10k\Omega$