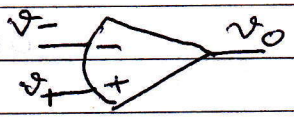
* OP AMP "IDEAL"

Analisis rangkaian Penguat Operasi (OP AMP) menggunakan assumsi OP-AMP "ideal", dengan karakteristik sebagai berikut :

I * Penguatan Tegangan $A_v = \infty$

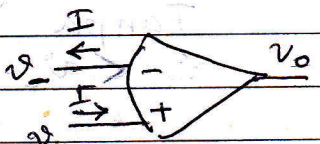


$$A_v = \frac{v_o}{v_+ - v_-} = \infty$$

Artinya $v_+ - v_- = 0$

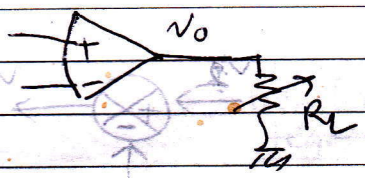
atau: $v_+ = v_-$

II * Impedansi Masukan $Z_i = \infty$



Arus $I = 0$ (tidak ada aliran arus keluar-masuk terminal v_+ dan v_-)

III * Impedansi Keluaran $Z_o = 0$

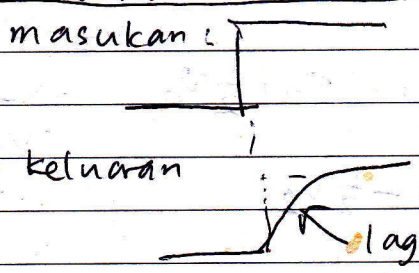


v_o tidak dipengaruhi R_L

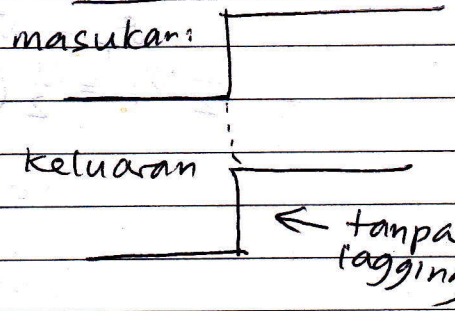
IV * Lebarpita Frekuensi $BW = \infty$

Perubahan isyarat masukan ditanggapi langsung tanpa lagging.

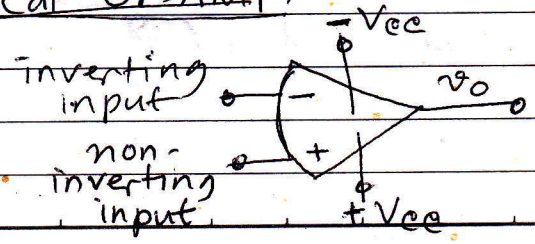
Bandwidth Tidak ∞



Bandwidth ∞



V * Practical OP-AMP:

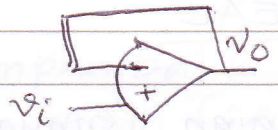


$$-V_{cc} < v_o < +V_{cc}$$

v_o tidak lebih dr. $+V_{cc}$
tidak kurang dr. $-V_{cc}$

* RANGKAIAN-RANGKAIAN DASAR OP-AMP

* Buffer / PENYANGGA



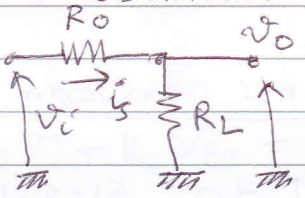
umpan-balik pada terminal v_- (inverting input) supaya tidak jenuh

Catatan: umpan balik pada non-inverting input akan mengakibatkan OP-AMP jenuh / saturasi → $v_o = +V_{cc}$ atau $-V_{cc}$

⇒ Kegunaan "Buffer" (Rangkaian Penyangga):

* Mengurangi efek pembebanan:

Tanpa "Buffer":



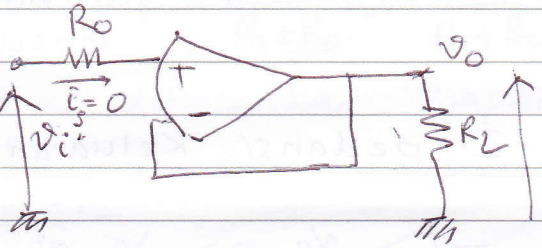
$v_o < v_i$

$i_s \neq 0$ (ditarik dari sumber)

$$v_o = \frac{R_L}{R_o + R_L} v_i$$

$$i_s = \frac{v_i}{R_o + R_L}$$

Dengan "Buffer"



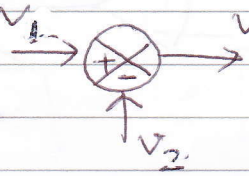
$v_o = v_i$

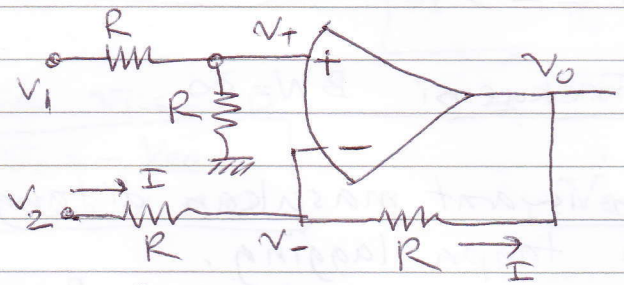
$i_s = 0$

Sifat I → $v_o = v_i = v_+ = v_-$

Sifat II → $i_s = 0$

* Pembanding / KOMPARATOR





$$v_+ = \frac{R}{R+R} v_1 = \frac{1}{2} v_1$$

$$I = \frac{V_2 - V_-}{R} = \frac{V_- - V_o}{R}$$

Menurut sifat I

$v_+ = v_-$

$\frac{1}{2} v_1 = \frac{1}{2}(v_2 + v_o) = \frac{1}{2} v_2 + \frac{1}{2} v_o$

$V_2 - V_- = V_- - V_o$

$2V_- = v_2 + v_o$

$V_- = \frac{1}{2}(v_2 + v_o)$

$\frac{1}{2} v_o = \frac{1}{2} v_1 - \frac{1}{2} v_2$

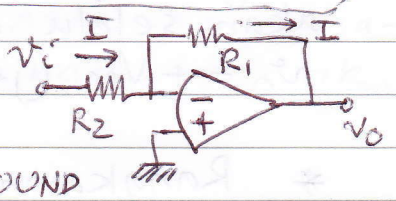
$$\boxed{v_o = v_1 - v_2}$$

* Penguat/Redaman

* Penguat/Redaman Membalik (Inverting Amplifier/Attenuator)

$$v_o = K v_i \quad , \quad K<0$$

Rangkaian:



Sifat I : $v_+ = v_- = 0$

v_+ : REAL GROUND

v_- : VIRTUAL GROUND

antara v_+ dan v_- ada $z_i = \infty$ (terisolasi)

Sifat II :

$$I = \frac{v_i - v_-}{R_2} = \frac{v_- - v_o}{R_1}$$

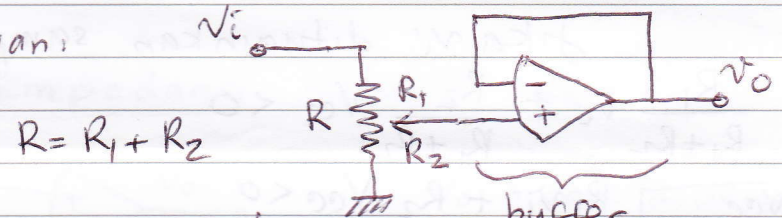
$$\frac{v_i}{R_2} = \frac{-v_o}{R_1}$$

$$\boxed{v_o = -\frac{R_1}{R_2} v_i} \qquad \boxed{K = -\frac{R_1}{R_2} < 0}$$

* Redaman Tak Membalik

$$\boxed{v_o = K v_i \qquad 0<K<1}$$

Rangkaian:



$R = R_1 + R_2$

$v_o = v_- = v_+$

$$v_+ = \frac{R_2}{R_1+R_2} v_i$$

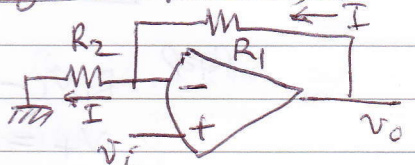
$$= \frac{R_2}{R} v_i$$

$$\boxed{v_o = \frac{R_2}{R_1+R_2} v_i = \frac{R_2}{R} v_i} \qquad \boxed{0 < K = \frac{R_2}{R_1+R_2} = \frac{R_2}{R} < 1}$$

* Penguat Tak Membalik (Non-Inverting Amplifier)

$$\boxed{v_o = K v_i \quad , \quad K>1}$$

Rangkaian:



Sifat I : $v_+ = v_- = v_i$

Sifat II :

$$I = \frac{v_o - v_-}{R_1} = \frac{v_-}{R_2}$$

$$\frac{v_o - v_i}{R_1} = \frac{v_i}{R_2} \longrightarrow \frac{v_o}{R_1} = \frac{v_i}{R_1} + \frac{v_i}{R_2} \longrightarrow v_o = v_i + \frac{R_1}{R_2} v_i$$

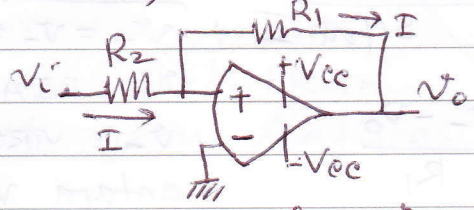
$$= \left(1 + \frac{R_1}{R_2}\right) v_i$$

$$\boxed{v_o = \left(1 + \frac{R_1}{R_2}\right) v_i} \qquad \boxed{K = \left(1 + \frac{R_1}{R_2}\right) > 1}$$

* Penguat Regeneratif (Regenerative Amplifier)

Jika OP-AMP diberi umpan-balik POSITIVE, maka akan selalu dalam keadaan jenuh (SATURATED), sehingga $v_o = +V_{cc}$ (jenuh positif) atau $v_o = -V_{cc}$ (jenuh negatif)

* Rangkaian:



* Jika $v_i >>> 0$

$$\boxed{v_o = +V_{cc}}$$
$$\boxed{v_+ > v_- > 0}$$

$$I = \frac{v_i - v_+}{R_2} = \frac{v_+ - V_{cc}}{R_1}$$

$$\frac{v_i}{R_2} + \frac{V_{cc}}{R_1} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right) v_+$$

$$R_1 v_i + R_2 V_{cc} = (R_1 + R_2) v_+$$

$$v_+ = \frac{R_1}{R_1 + R_2} v_i + \frac{R_2}{R_1 + R_2} V_{cc}$$

Jika v_i diturunkan sampai $v_+ < 0$,

atau: $\frac{R_1}{R_1+R_2} v_i + \frac{R_2}{R_1+R_2} V_{cc} < 0$

$$R_1 v_i + R_2 V_{cc} < 0$$
$$R_1 v_i < -R_2 V_{cc}$$
$$\boxed{v_i < -\frac{R_2}{R_1} V_{cc}}$$ maka $\boxed{v_o = -V_{cc}}$

$$\boxed{LTP = -\frac{R_2}{R_1} V_{cc} \quad \text{(Lower Trip Point)}}$$

* Jika $v_i <<< 0$

$$\boxed{v_o = -V_{cc}}$$
$$\boxed{v_+ < v_- < 0}$$

$$I = \frac{v_o - v_+}{R_1} = \frac{v_+ - v_i}{R_2}$$

$$\frac{-V_{cc} - v_+}{R_1} = \frac{v_+ - v_i}{R_2}$$

$$\frac{v_i}{R_2} - \frac{V_{cc}}{R_1} = \frac{v_+}{R_1} + \frac{v_+}{R_2} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right) v_+$$

$$R_1 v_i - R_2 V_{cc} = (R_1 + R_2) v_+$$

$$v_+ = \frac{R_1}{R_1+R_2} v_i - \frac{R_2}{R_1+R_2} V_{cc}$$

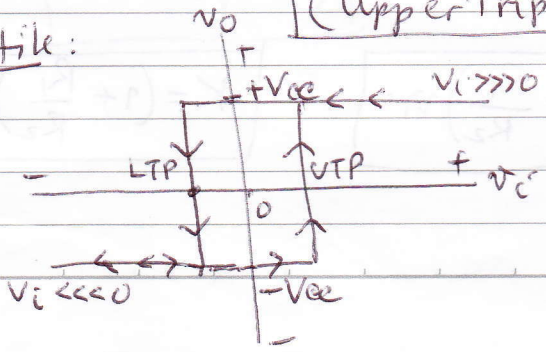
Jika v_i dinaikkan sampai $v_+ > 0$, atau:

$$\frac{R_1}{R_1+R_2} v_i - \frac{R_2}{R_1+R_2} V_{cc} > 0 \rightarrow R_1 v_i - R_2 V_{cc} > 0 \rightarrow \boxed{v_i > \frac{R_2}{R_1} V_{cc}}$$

$$\boxed{UTP = \frac{R_2}{R_1} V_{cc} \quad \text{(Upper Trip Point)}}$$

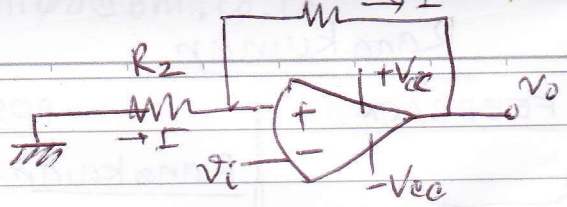
maka: $\boxed{v_o = +V_{cc}}$

Karakteristik:



Hysterisis Tegale
Window Comparator
Schmitt Trigger

* Rangkaian



* Jika $v_i >>> 0$

$$\boxed{v_o = -V_{cc}}$$

$$\boxed{v_+ < v_-}$$

$$I = \frac{-v_+}{R_2} = \frac{v_+ - v_o}{R_1}$$

$$\frac{-v_+}{R_2} = \frac{v_+ + V_{cc}}{R_1}$$

$$-\left(\frac{1}{R_1} + \frac{1}{R_2}\right) v_+ = \frac{V_{cc}}{R_1}$$

Jika v_i diturunkan:

sampai $v_i < v_+$

atau $\boxed{v_i < -\frac{R_2}{R_1+R_2} V_{cc}}$ LTP

$$-(R_1+R_2)\, v_+ = R_2 V_{cc}$$

$$v_+ = -\frac{R_2}{R_1+R_2} V_{cc}$$

maka $\boxed{v_o = +V_{cc}}$

* Jika $v_i <<< 0$

$$\boxed{v_o = +V_{cc}}$$

$$\boxed{v_+ > v_-}$$

$$I = \frac{v_o - v_+}{R_1} = \frac{v_+}{R_2}$$

$$\left(\frac{1}{R_1} + \frac{1}{R_2}\right) v_+ = \frac{v_o}{R_1} = \frac{V_{cc}}{R_1}$$

Jika v_i dinaikkan:

sampai $v_i > v_+$

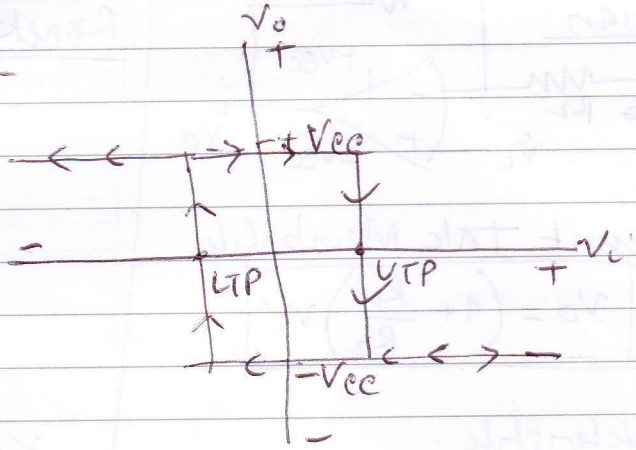
$$(R_1+R_2)\, v_+ = R_2 V_{cc}$$

$$v_+ = \frac{R_2}{R_1+R_2} V_{cc}$$

atau $\boxed{v_i > \frac{R_2}{R_1+R_2} V_{cc}}$ UTP

maka $\boxed{v_o = -V_{cc}}$

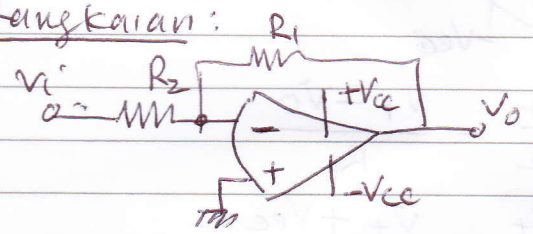
Karakteristik:



Rangkuman :

NEGATIVE FEEDBACK

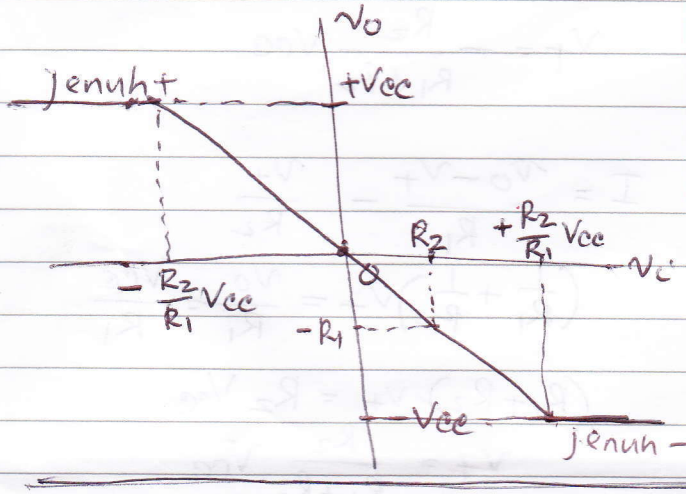
Rangkaian :



Penguat Membalik

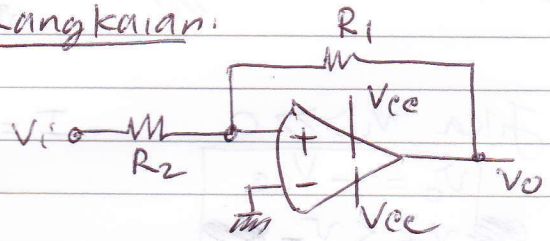
$$v_o = -\frac{R_1}{R_2} v_i$$

Karakteristik :



POSITIVE FEEDBACK

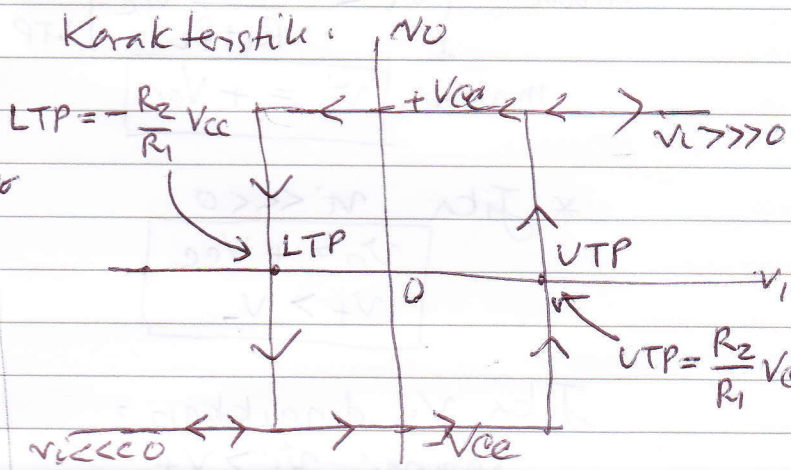
Rangkaian :



Penguat Regenatif :

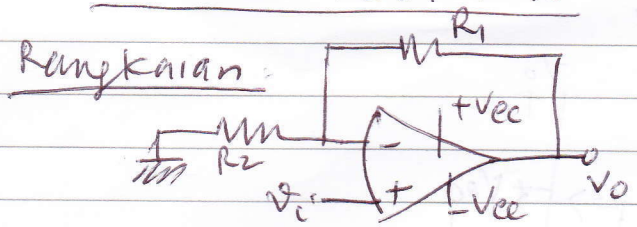
$$v_o \begin{cases} = +V_{cc}, & v_i >>> 0 \\ = -V_{cc}, & v_i <<< 0 \end{cases}$$

Karakteristik :



NEGATIVE FEEDBACK

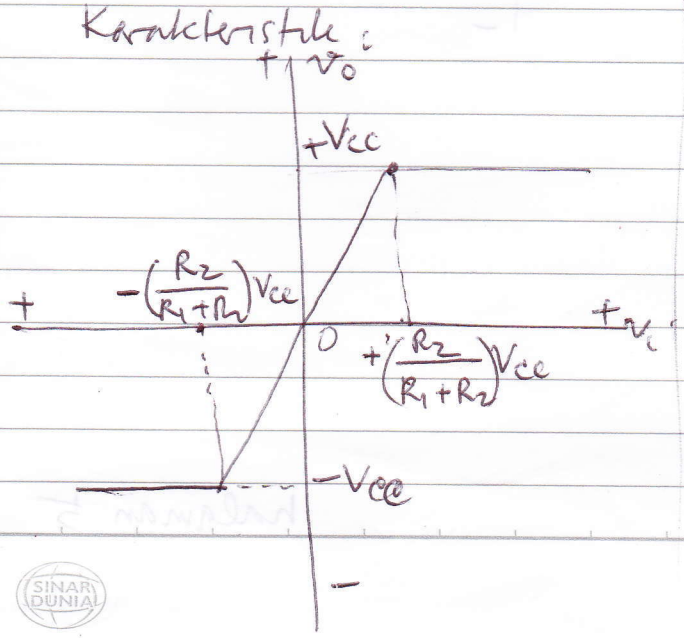
Rangkaian :



Penguat Tak Membalik

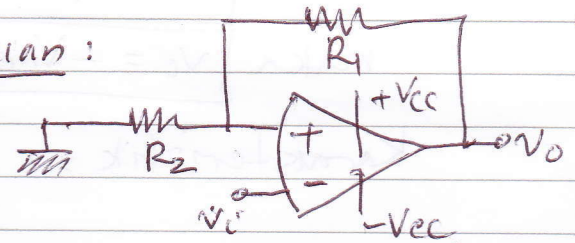
$$v_o = \left(1 + \frac{R_1}{R_2}\right) v_i$$

Karakteristik :



POSITIVE FEEDBACK

Rangkaian :



Penguat Regeneratif :

$$v_o \begin{cases} = +V_{cc}, & v_i <<< 0 \\ = -V_{cc}, & v_i >>> 0 \end{cases}$$

Karakteristik :