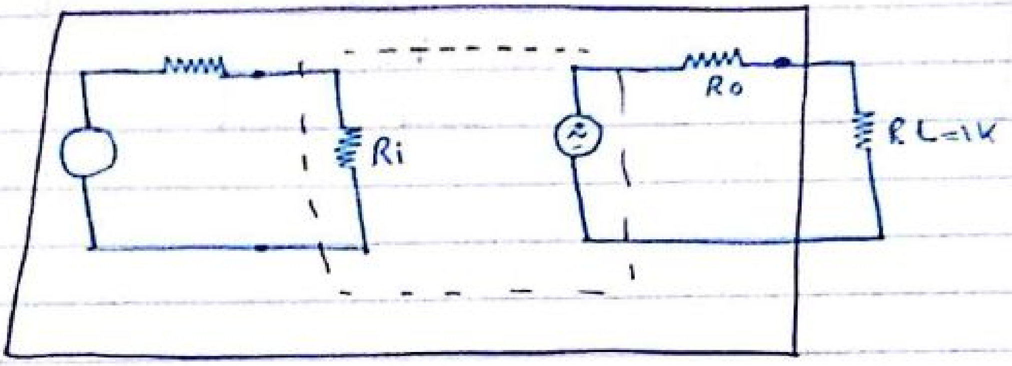
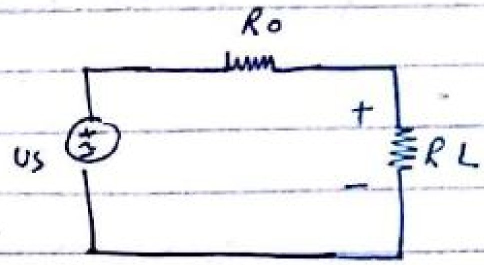
3/8/2017

* Emitter follower → The output voltage follows the Emitter voltage :



Current Amplifie
Voltage buffe

↓



- The Common Collector is usually designed to have a $A_V=1$ with very low Ro and very high Ri.

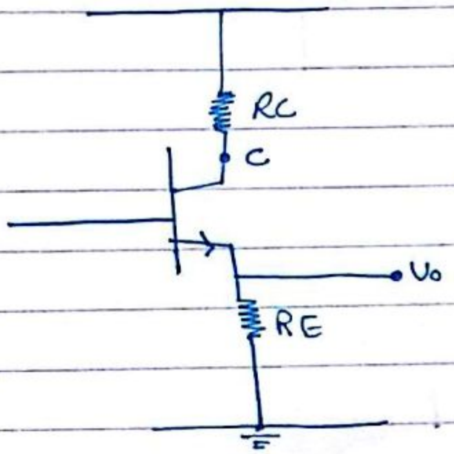
hence, It acts as a buffer CKT without voltage gain ≈ 1, but with current gain, so we still get power Amplification.

even if there is RC It's still a common collector CKT.

6/8/2017

⇒ Common collector :-

O/p
من عند E



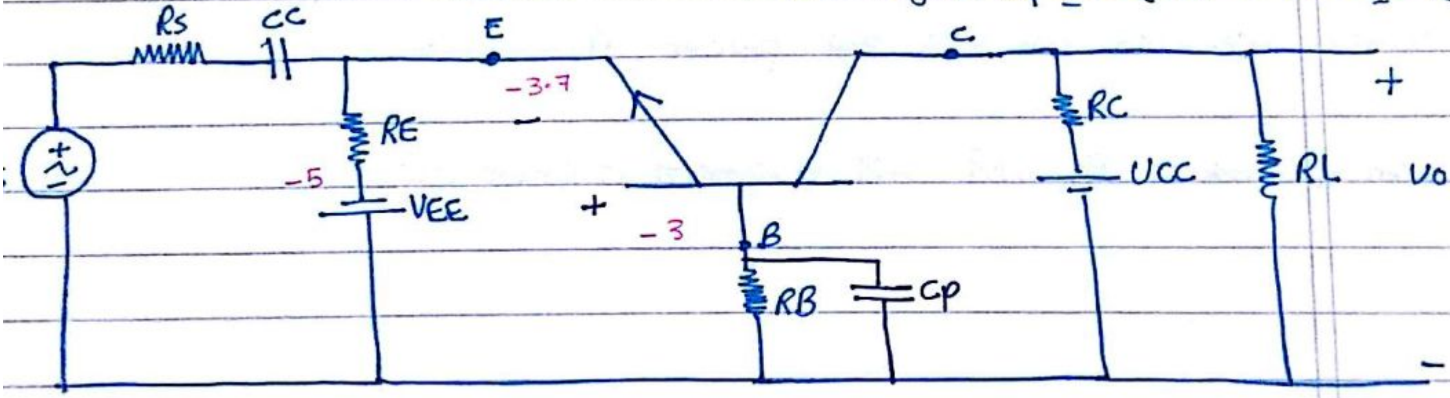
⇒ It is still a common collector CKT.

Rc* ما إلها دور في βib إلها دور في أشياء ثانية.

(منطقياً الدارة بوجود Rc تختلف عن عدم وجودها)

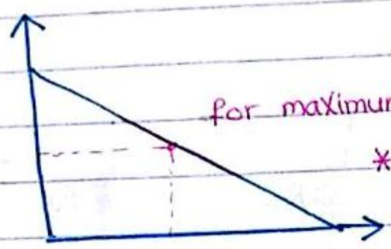
* The common Base Amplifier :-

⇐ منها Ai ، أهميتها في ال AC signal.



$(-3) - (-3.7) = 0.7$

* I_C مالوه علاقة في ال Vcc فقط علاقته مع IB .
* Vcc و RC حتى نضبط UCE .



* $U_{CE} = \frac{1}{2} U_{CC}$ In Amplifier

* Coupling Capacitor (CC) ⇒ بجمع 2 signals مع بعض

* ال signal بتدخل من عند E (i/p) وبتطلع من عند C (o/p) .

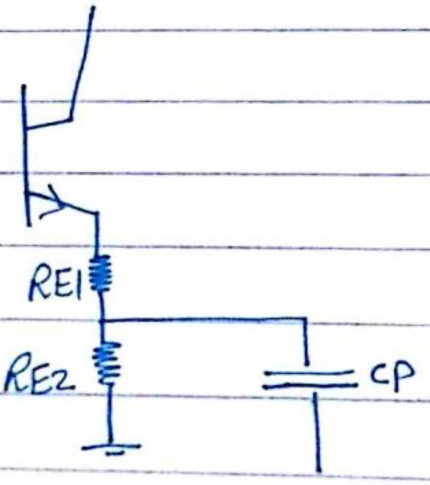
* ال B مش موصول مع ال ground مباشرة حتى نوصلها بنستخدما مع Capacitor في حالة ال AC بصير Short CKT .

⇓

by pass Capacitor (cp)

بغير اتجاه التيار (تحويلة)

common Emitter with bypass capacitor:

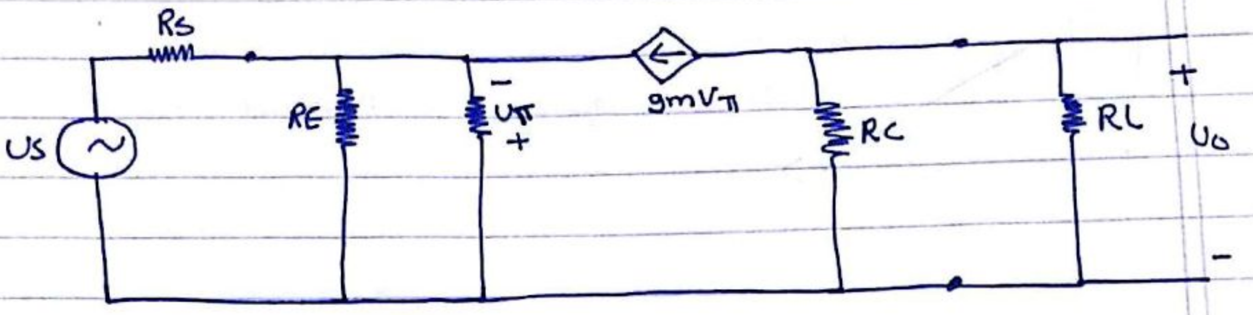


* note :- VBE ON = 0.7

$V_{be} \neq 0.7 = r_\pi \, i_b$

* Common Base ⇒ Ac eq. CKT انقص دورها من ال RB

* The Ac eq. CKT is as shown :>



* It can be shown (see book) that: الاشتقاق مهم من الكتاب

[1] $A_V = g_m (R_C // R_L)$ with Justification.

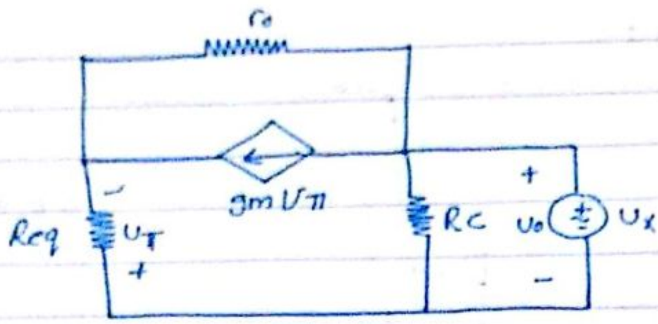
[2] $A_i = \frac{I_o}{I_i} = \frac{\beta}{1+\beta} = \alpha \approx 1$ $(= 0.998 < 1)$ with Justification.

[3] $R_{ie} \approx \frac{r_\pi}{1+\beta}$ with Justification منها صغيرة جداً.

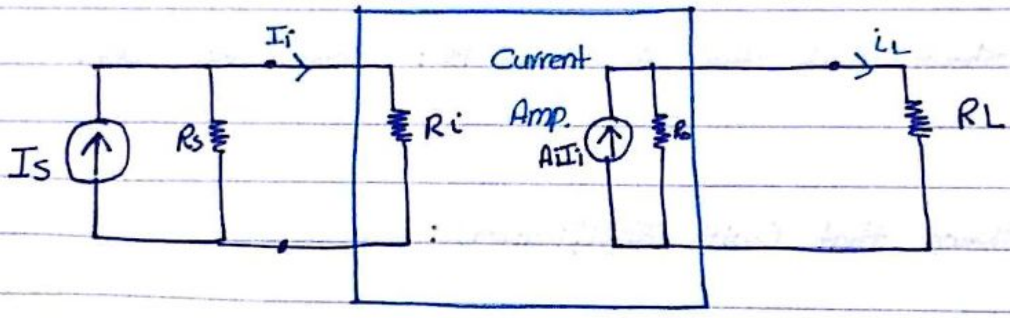
[4] $R_o \approx r_o // R_C$ 〃 〃

* Note : (In the exam) :
⇒ Derive, Show that, obtain ⇒ اشتق

⇒ write down, list, mention, use ⇒ استخدم بدون اشتقاق



* Since A_i is almost 1, R_{ie} is very low (i/p resistance) and the (o/p resistance) is very high, then the common Base Amplifier acts as a current Buffer.

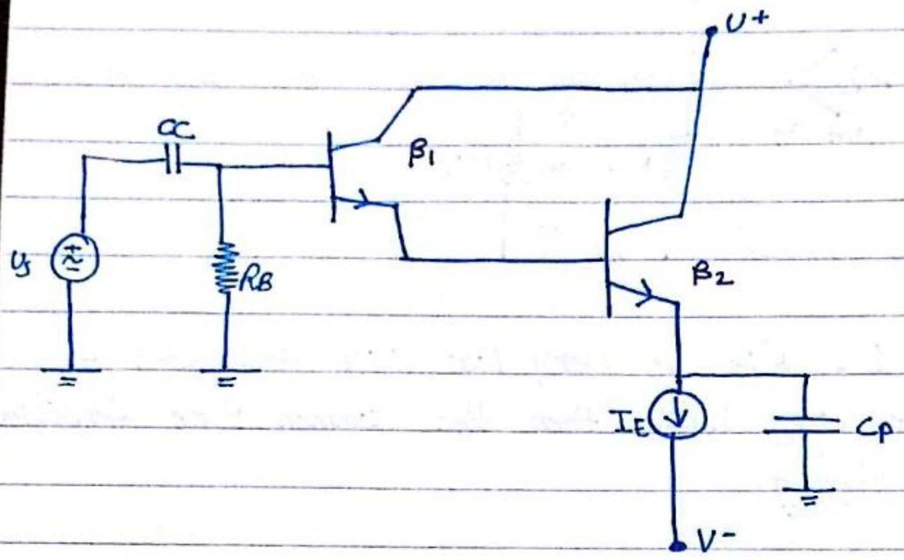


$$I_i = \frac{R_s}{R_s + R_i} I_s$$

$$i_L = \frac{R_o}{R_o + R_L} (A_i I_i)$$

* The Darlington Pair :-

7/8/2017



** It has very high current gain.

⇒ It can be shown that the AC model is : (from book)

* It can be shown that (with Justification) :

[1] $A_i \approx \beta_1 \beta_2 \approx 10^4 \gg 1$ (very high)

[2] $R_i \approx 2\beta_1 r_{\pi 2}$ ⇒ considered very large.

* Ai very high, why?

$A_i = (1+\beta_2)\, i_{b2}$

$(1+\beta_2)\, i_{e1}$

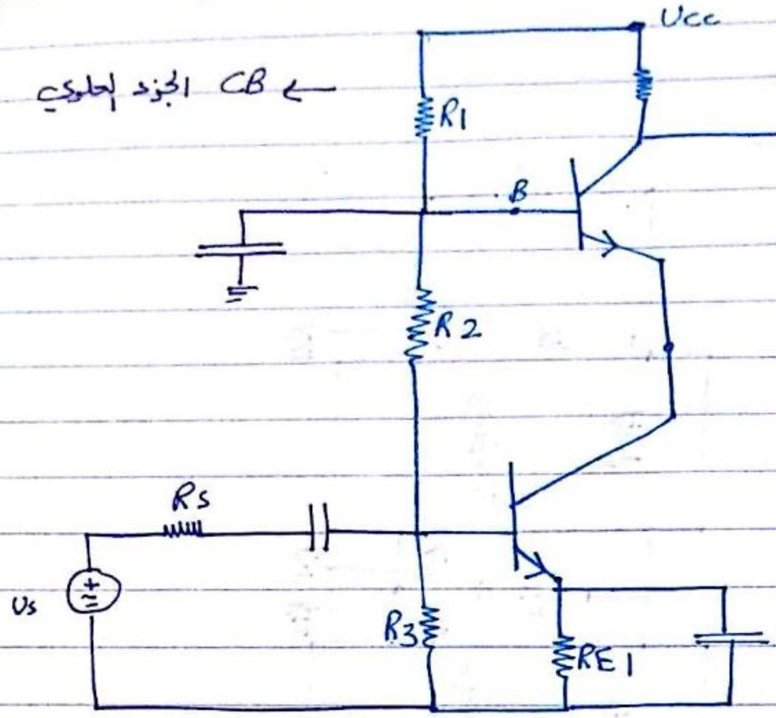
$(1+\beta_2)(1+\beta_1)\, i_{b1}$

$I_i = i_{b1}$

* The Cascade Amplifier :>

↳ It is : a common Emitter (CE) stage driving a CB stage.

CB ← الجزء العلوي



(Electronic CKT)

* It can be shown that the AC CKT model is (see book) :>

* electronic CKT → Transistors فيها.

* AC CKT → (sources, R, C, ..) العادية CKT فيها مكونات الـ Transistors ما فيها

* It can be shown that (with Justification) :_

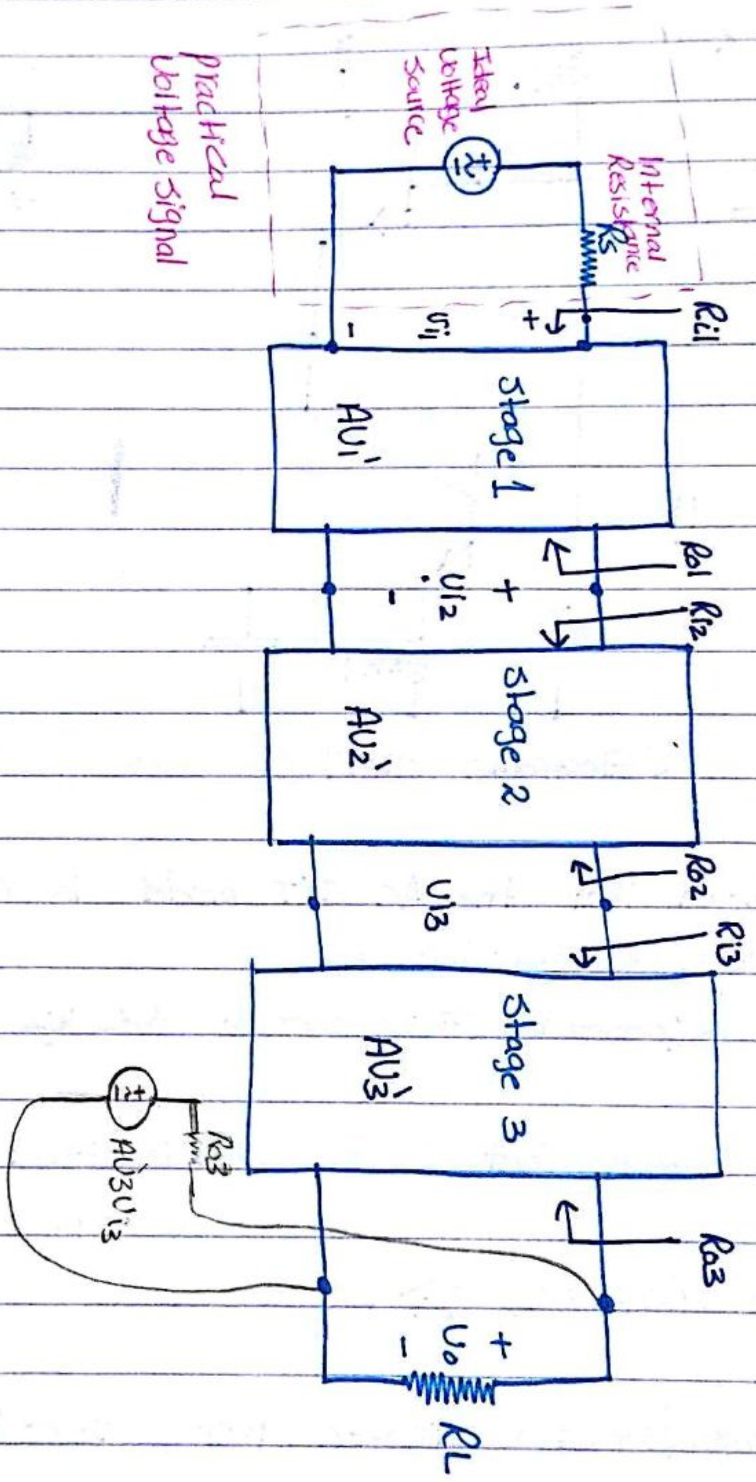
[1] $A_V \approx -g_{m1} (R_C \parallel R_L) \gg -1$

* Multistage Amplifier ⇒ Darlington pair , cascode Amplifier.

2/8/2017

* Multistage Amplifier :

↳ A multi stage Amplifier represented schematically as :



$$* \quad V_o = \frac{R_L}{R_L + R_{o3}} A_{V3}' V_{i3}$$

$$V_{i3} \rightarrow \frac{R_{i3}}{R_{i3} + R_{o2}} A_{V2}' V_{i2}$$

$$V_{i2} \rightarrow \frac{R_{i2}}{R_{i2} + R_{o1}} A_{V1}' V_{i1}$$

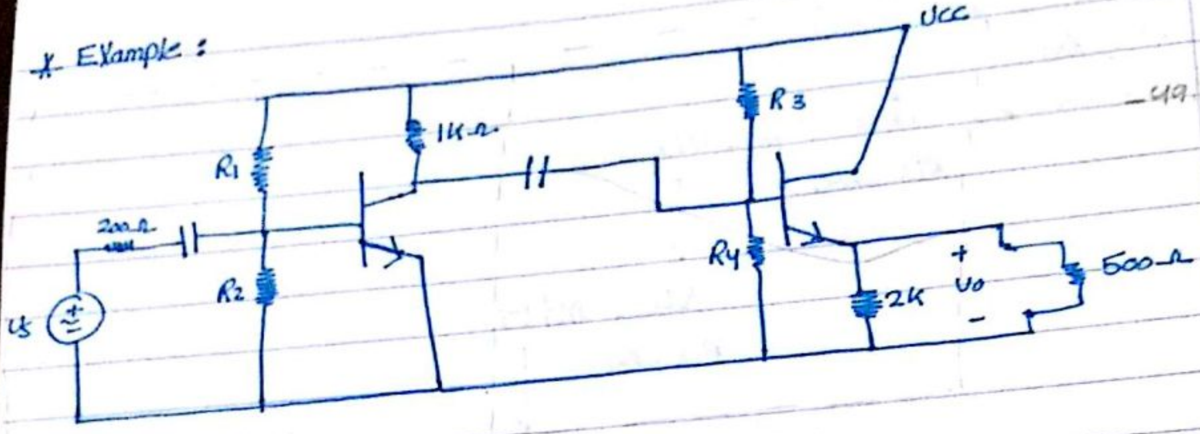
$$V_{i1} \rightarrow \frac{R_{i1}}{R_{i1} + R_s} V_s$$

$$\Rightarrow A_V = \frac{V_o}{V_s} = \frac{R_L}{R_L + R_{o3}} A_{V3}' \frac{R_{i3}}{R_{i3} + R_{o2}} A_{V2}' \frac{R_{i2}}{R_{i2} + R_{o1}} A_{V1}' \frac{R_{i1}}{R_{i1} + R_s} \quad **$$

where A_V' is the gain defined with respect to V_i and not with respect to V_s.

*في مثال في الكتاب كرم خله بنفس الطريقة التي درنا نحل فيها الـ Example ⇐.

* Example :



$-49.5 \frac{500}{500+1000}$
$= -16,...$

→ Common Emitter ←——→ Common Collector ←

* Assume $R_1 // R_2 = \infty\ \Omega$, $R_3 // R_4 = \infty\ \Omega$, $R_{o1} = R_{o2} = \infty\ \Omega$
$\beta_1 = \beta_2 = 99$, $r_{\pi 1} = r_{\pi 2} = 2K\ \Omega$.

* Stage 1 : is CE :

$R_{i1} = \underbrace{R_1 // R_2}_{\infty} // \underbrace{(r_{\pi_1} + (1+\beta_1) \overset{0\ \Omega}{R_{E1}})}_{R_{ib}} = r_{\pi 1} = 2K\ \Omega$

$R_{o1} = R_{C1} = 1K\ \Omega$

$$A_{V1}' = \frac{-\beta R_C}{r_\pi + (1+\beta) R_{E1}} = \frac{-99 \times 1K}{2K} = -49.5$$

* Stage 2: IS CC :

$R_{i2} = R_1 \overset{\infty}{//} R_2 // (r_{\pi 2} + (1+\beta)(r_{o2}//R_{E2})) = 202\ k\Omega$

$2 + 100 \times 2$

$A_{v2}' = \frac{(1+\beta)(R_{E2}//r_{o2})}{r_\pi + (1+\beta)(R_{E2}//r_{o2})} = \frac{200}{202} = 0.99$

$R_{o2} = \frac{r_{\pi 2} + R_S}{1+\beta} = \frac{2.2k}{100} = 22\ \Omega$ قليلة

$\Rightarrow A_V = \frac{V_o}{V_S} = \frac{R_L}{R_L + R_{o1}} A_{V3}' \frac{R_{i3}}{R_{i3} + R_{o2}} A_{V2}' \frac{R_{i2}}{R_{i2} + R_{o1}} A_{V1}' \frac{R_{i1}}{R_{i1} + R_S}$

(In between = 1)

$= \frac{500}{522} \times 0.99 \frac{2}{2+1} \times -49.5 = -31.2$

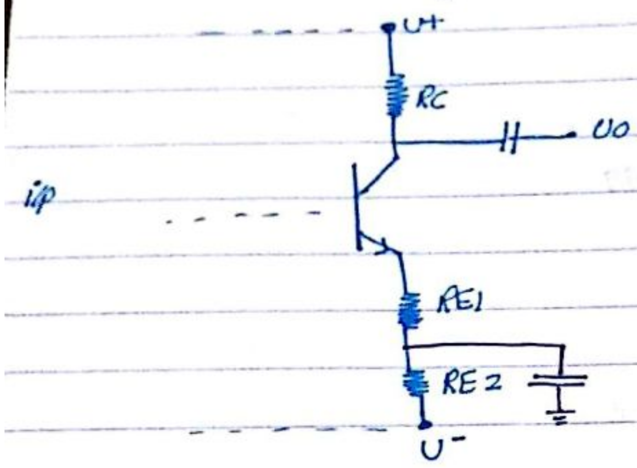
أقل من الـ AV لـ CE ثلاثة !!

لا CC نقلل الـ output Resistance

9/8/2017

* Dc and AC load lines :

* consider the following CKT :

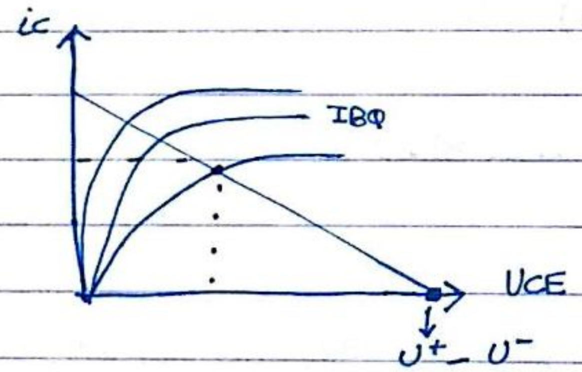


* الـ load line إله علاقة بدائرة الـ output وليس بـ input.

* الـ ⊣⊢ عند RE2 هي بتزيد AU.

⇒ Dc load line : (capacitors → open CKT)

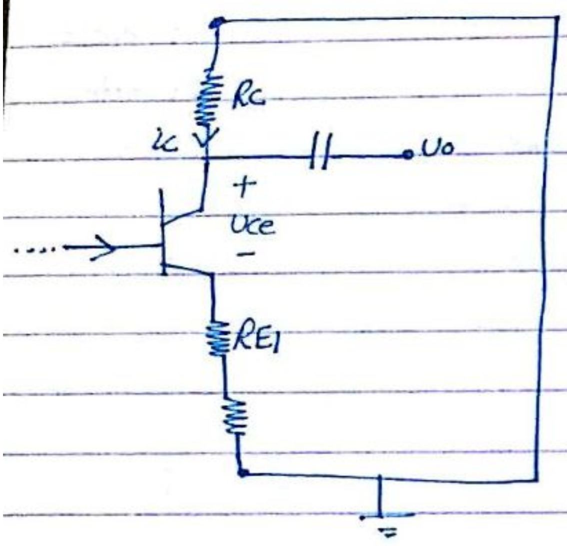
$$U^+ = R_C I_{CQ}^* + U_{CEQ}^* + (R_{E1} + R_{E2}) \underbrace{\frac{\beta+1}{\beta} I_{CQ}}_{I_E} + U^-$$

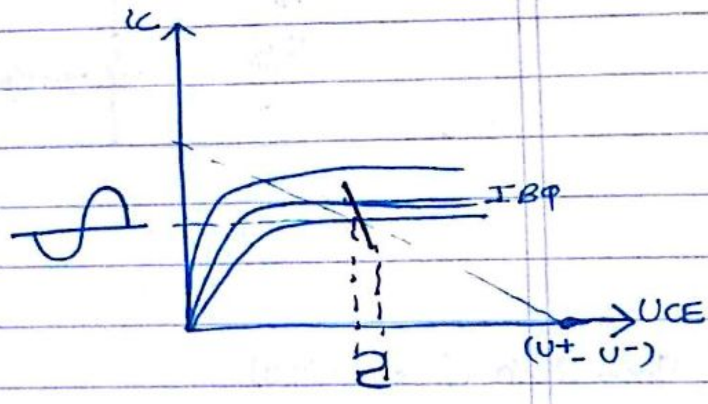


* AC load line :

$$R_C\, i_C + R_{E1}\, i_e + U_{ce} = 0$$

$$\left(R_C + \frac{\beta+1}{\beta} R_{E1}\right) i_C + U_{ce} = 0$$





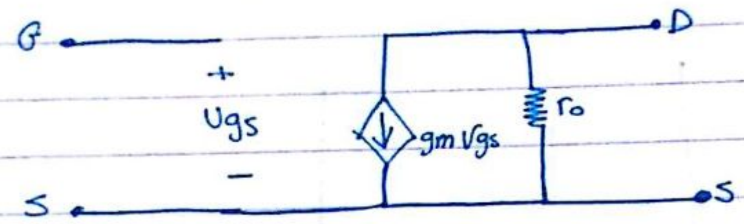
* Ch 4 : FET Amplifier circuit.

↳ higher backing Density حجمه الصغير بخلي

⇒ The small signal low freq. model of n-channel MOSFET :

* 10/8/2017

- It can be shown that a model of N-mos transistor is :



D: Drain

S: Source

G: Gate

IG=0

* gm Vgs لا تكتب بطريقة أخرى لأنه IG=0

$$g_m = 2K_n (V_{GS} - V_{TN})$$
$$= 2\sqrt{K_n I_{DQ}}$$

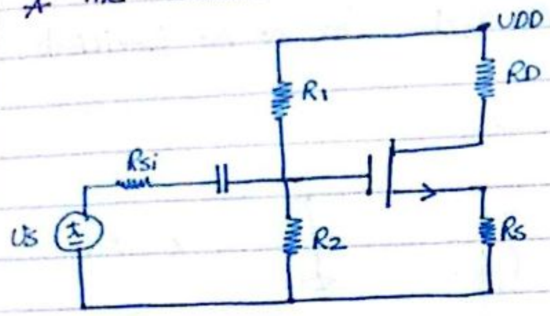
$$r_o = \frac{1}{\lambda I_{DQ}}$$

$I_D = K_n (V_{GS} - V_{TN})^2$ → Saturation mode.

* The Common Source Amplifier :

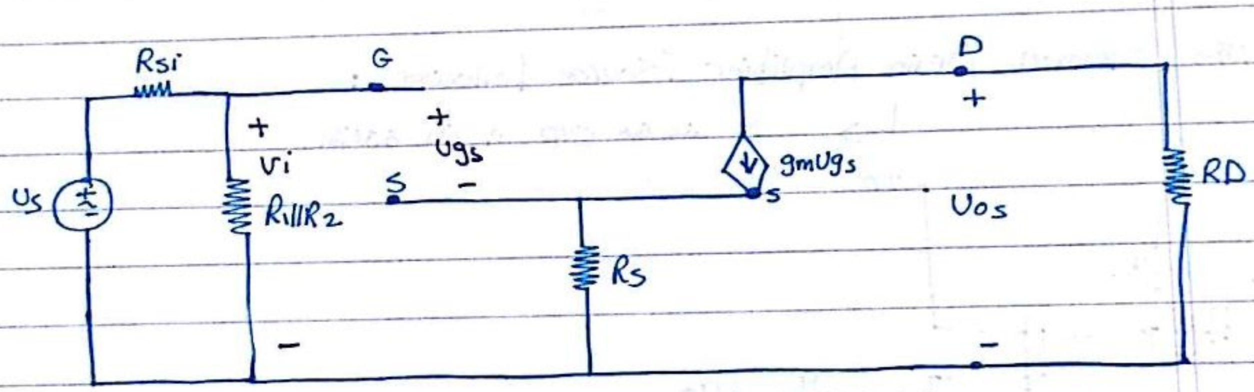
R_{si} : Input source

R_S : source



$I_D = I_S$

$i_d = i_s$



$V_o = -g_m V_{gs} R_D$

$V_i = V_{gs} + g_m V_{gs} R_S$

$\Rightarrow V_{gs} = \frac{1}{1 + g_m R_S} V_i$

$V_o = \frac{-g_m R_D}{1 + g_m R_S} V_i$

$\downarrow$

$V_o = \frac{-g_m R_D}{1 + g_m R_S} \cdot \frac{R_1 \| R_2}{R_1 \| R_2 + R_{si}} V_s$

(39)

$* A_V = \frac{V_o}{V_s} = \underbrace{\frac{-g_m R_D}{1 + g_m R_S}}_{P_1} \cdot \underbrace{\frac{R_1 \| R_2}{R_1 \| R_2 + R_{si}}}_{P_2}$

* أكبر قيمة ممكن ل AV اذا كان P2 = 1 وبتكون = P1

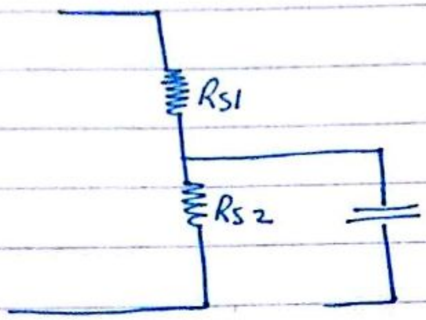
* لهيك نخليها بتكبر R1||R2

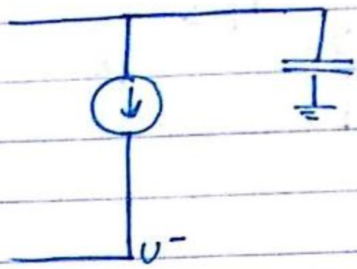
* Rsi ما بنقدر نتحكم فيها

لأنه

design مش

$$A_V \approx \frac{-g_m R_D}{1+g_m R_S} \approx \frac{-R_D}{R_S} \quad \text{if } g_m R_S \gg 1$$ (has to be justified)

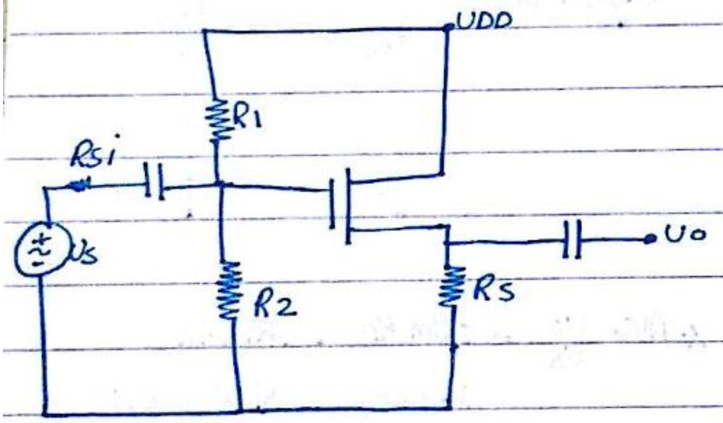


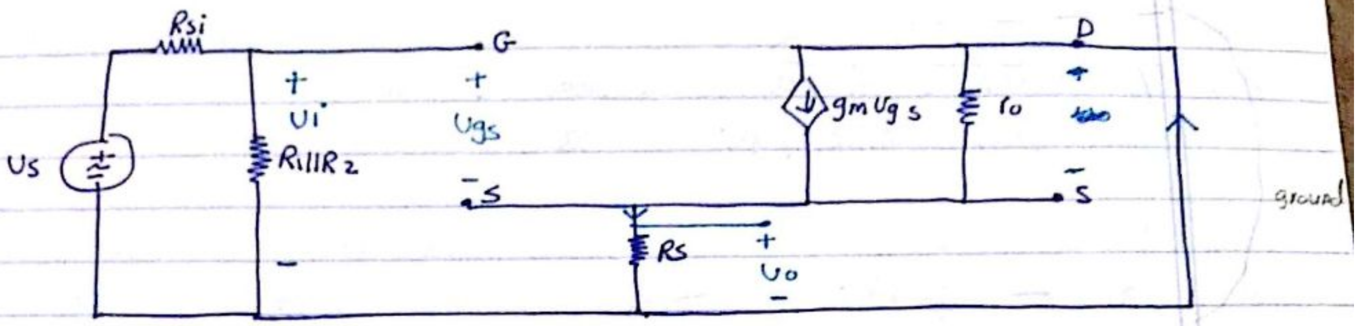


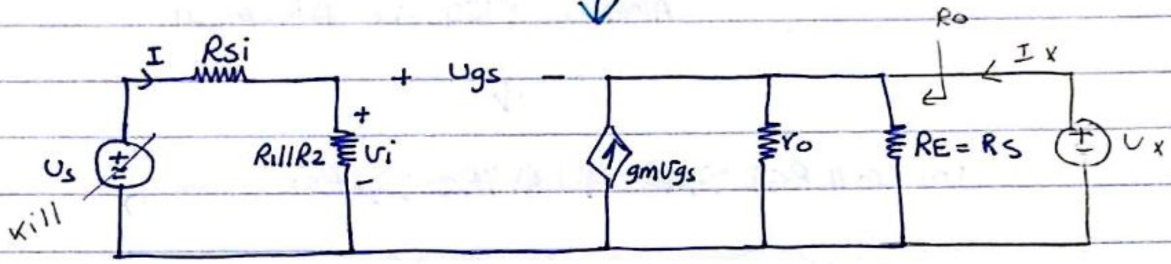
No RI.

✱ The common Drain Amplifier (source follower) :>

↳ الفائدة أنه اد o/p من عند S







لـ Vi = 0 بنشله طاقة Source

$V_o = g_m V_{gs} (r_o // R_E)$

$V_i = V_{gs} + g_m V_{gs} (r_o // R_E)$

$$V_{gs} = \frac{1}{1 + g_m (r_o // R_E)} \cdot \underbrace{\frac{R_1 // R_2}{R_1 // R_2 + R_{si}} V_s}_{V_i}$$

$$V_o = \frac{g_m (r_o // R_E)}{1 + g_m (r_o // R_E)} \cdot \frac{R_1 // R_2}{R_1 // R_2 + R_{si}} \cdot V_s$$

$$A_V = \frac{g_m (r_o \| R_E)}{1 + g_m (r_o \| R_E)} \cdot \frac{R_1 \| R_2}{R_1 \| R_2 + R_{si}} = \frac{V_o}{V_s}$$

$R_1 \| R_2 \gg R_{si}$

البسط أقل من المقام ← $A_V < 1$

↓

$g_m (r_o \| R_E) \gg 1$ & $R_1 \| R_2 \gg R_{si}$

$A_V \approx 1$

$$R_o = \frac{V_x}{I_x}$$

$(R_{si} \cdot I + R_1 \| R_2) I = 0$

$I = 0 \rightarrow V_i = 0$

$0 + V_{gs} + V_x = 0$

$$\boxed{V_{gs} = -V_x}$$

$$I_x + g_m V_{gs} = \frac{V_x}{R_E \| r_o}$$

$$I_x = \left(g_m + \frac{1}{r_o \| R_E} \right) \cdot V_x$$

$$\frac{1}{R_o} = g_m + \frac{1}{r_o \| R_E} \rightarrow R_o = \frac{1}{g_m} \| (r_o \| R_s)$$

$\frac{1}{g_m} \rightarrow$ مقاومة , g_m: conductance

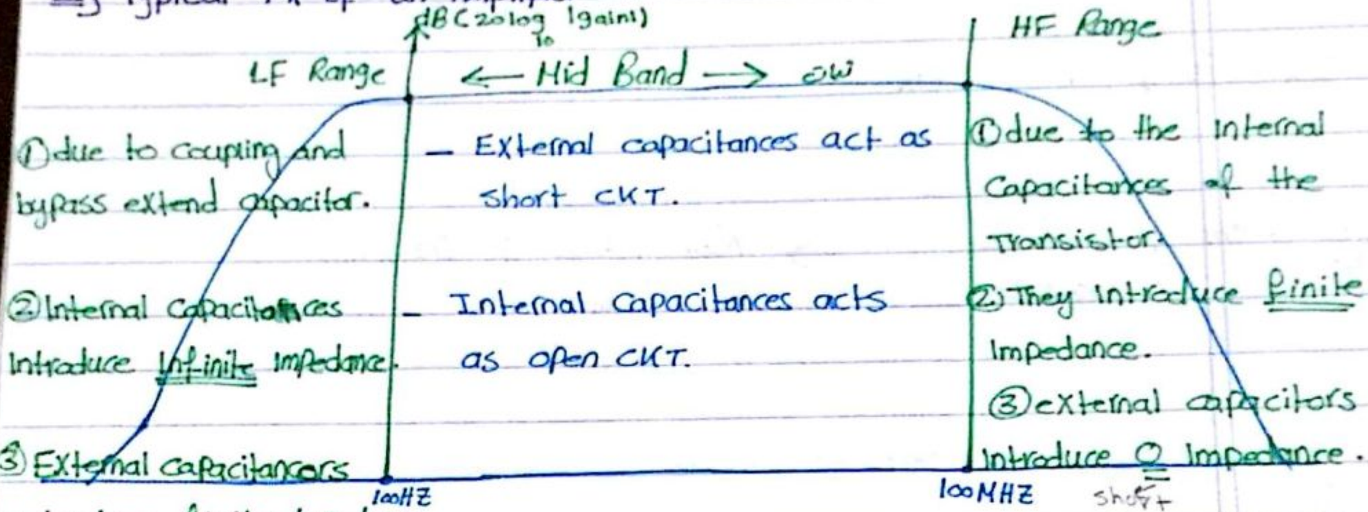
$$R_o = \frac{1}{g_m} \| R_s \quad \text{if } r_o \gg R_s .$$

* EX: Derive A_V, R_i, R_o for :
  i) The common source configuration.
  ii) " " Drane "
  iii) " " Gate "

* Ch 7 : Frequency Response of Amplifiers (FR) :>

13/8/2017

=) Typical FR of an Amplifier :



LF Range:

① due to coupling and bypass extend capacitor.

② Internal capacitances introduce Infinite impedance.

③ External capacitancers introduce finite impedance.

Mid Band:

– External capacitances act as short CKT.

– Internal capacitances acts as open CKT.

HF Range:

① due to the internal capacitances of the Transistor.

② They introduce finite impedance.

③ external capacitors introduce 0 impedance. short

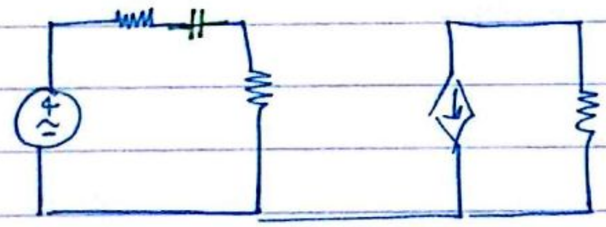
* ال internal إلهم قيمة لا يمز

ول لا short و open

*(Boding plot → compress Information)

* الصفر عن ممثل

* Frequency component : Capacitors and Inductors



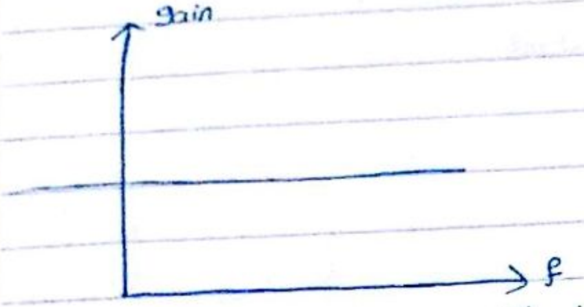
* Internal Impedance = PF

قيمها قليلة جدا

* External Impedance = μF

$$Z = \frac{1}{\omega C}$$

14/8/2017



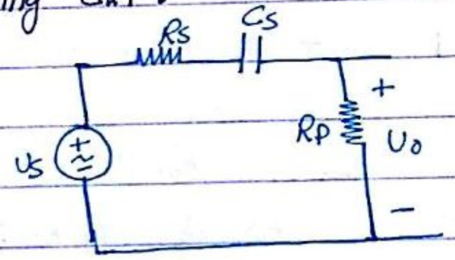
Amplifier characterstic without C&L (Ideal Amplifier)

* Coupling & bypass capacitor → low frequency

* Internal capacitors → High frequency

* short and open circuit Time constant :

- given the following ckT :



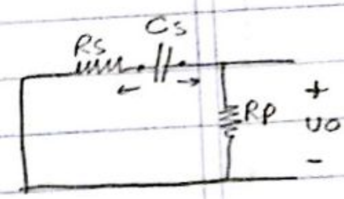
* Time constant معرف
عال first order فقط

$$\frac{V_o(s)}{V_s(s)} = \frac{R_p}{R_p + R_s + \frac{1}{sC_s}} = \frac{sR_pC_s}{1 + s\underbrace{(R_p + R_s)C_s}_{\tau}} = \frac{A}{1 + \tau s}$$

1 : dimension less → τs : dimension less → τ = second , $s = \frac{1}{\text{second}}$

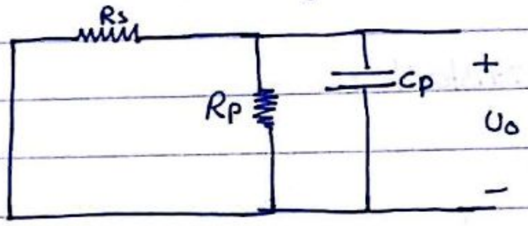
* $\tau = (R_p + R_s) C_s$ known as time constant.

$R_p + R_s$ → from CKT → kill V_s → short CKT → calculate equ. Resistance from Capacitor point of view



* i.e to get τ by Inspection kill the Independent source and obtain Req from the capacitor point of view.

* Consider now the following CKT :

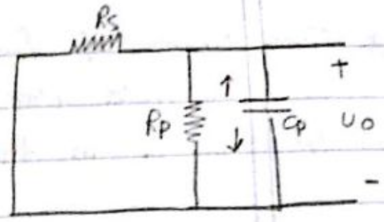


$$\frac{V_o(s)}{V_s(s)} = \frac{R_p \,//\, \frac{1}{sC_p}}{(R_s + R_p) \,//\, (1/sC_p)} = \frac{R_p}{R_p + R_s + sR_pR_sC_p}$$

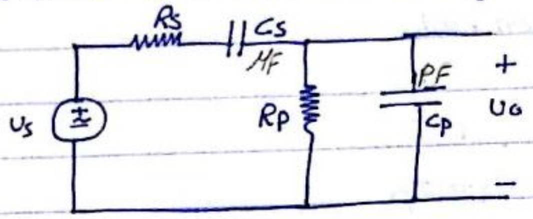
$$= \frac{R_p / (R_p + R_s)}{1 + \underbrace{((R_pR_s)/(R_p + R_s))\, C_p}_{\tau}\, s}$$

So, $\tau_p = (R_p \,//\, R_s) C_p = \frac{R_p R_s}{R_p + R_s} C_p$

* same procedure to find τ by Inspection.
(kill v_s → short CKT .....)



* Consider now the following CKT :



⇒ Assume the two time constants are very well far apart.

* for Ranges of freq. where Cs has moderate Impedance value, Cp will have very large Impedance value, to the extent of considering it ∞ Ω In this case:

$$\tau_s = (R_p + R_s) C_s$$

Known as the open CKT time Constant.

*اذا عني 2 ‖ ما بقدر أدمجلهم
ملها بكون 2nd order sys. equ.
↓
بشكل تقريبي في حالات معينة ممكن
أعتبره (1st order) 2 مضروبين
ببعض ← حتى أقدر أجيب τ لأنه
τ فقط لل 1st order.
↓
الحالات مثل أنه واحد منهم بال mF
والثاني nF (النسبة بينهم عالية)
↓
far apart
↓
بقدر أوجد τ by Inspection
↓
جذور المقام اذا كانوا بعاد عن
بعض بزبط اذا لا ما
بزبط.
↓
ال Transistors الي بندرسها
بزبط ✓

(47)

$Z = 1/\omega C$

* For Ranges of frequencies where Cp has moderate Impedance value, Cs will have very small Impedance value, to the extent of considering it 0Ω. In this case:

$$\tau_p = (R_p \parallel R_s) C_p$$

Known as the Short CKT time constant.

So, $f_L = \frac{1}{2\pi \tau_s}$, $f_H = \frac{1}{2\pi \tau_p}$

↦ Bandwidth = fH - fL ⟵|

↓

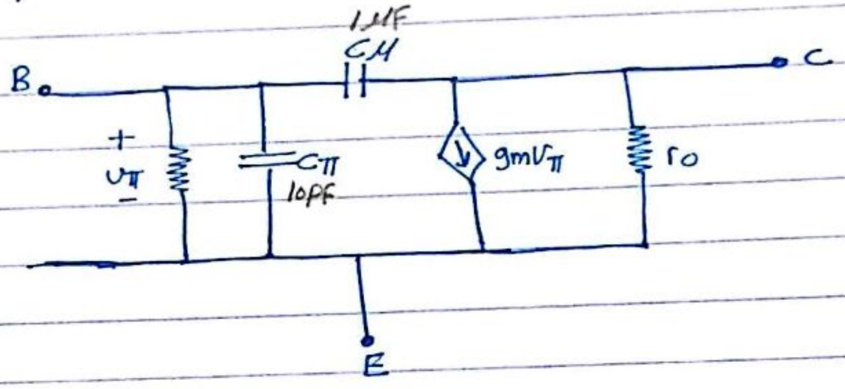
ال Range of freq اللي بكون عندهم مقدار ال Gain ثابت

(إضافي) 14/8/2017

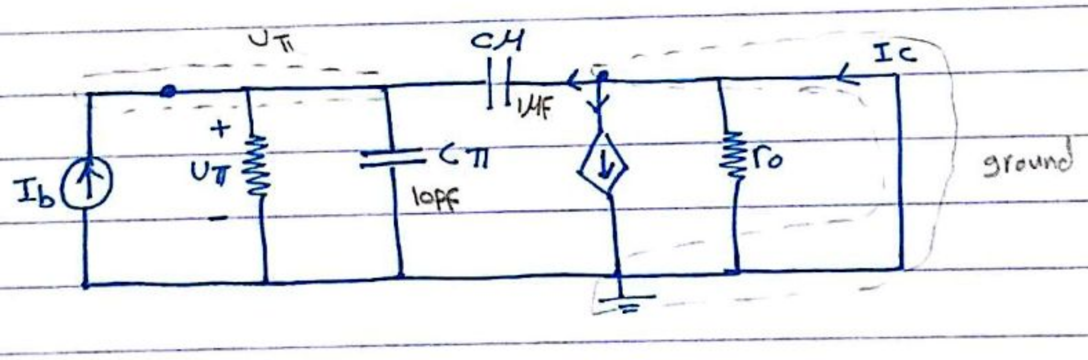
* Time Response (p 463 – P 501) → غير مطلوب

* Frequency Response of BJT (p. 502).

⇒ It can be shown that the small signal high freq. model of npn BJT can be simplified as shown:



* Short CKT current gain of a CE transistor Amplifier.



$$I_c = g_m v_\pi + j\omega (0 - v_\pi) C_\mu \quad = (g_m - j\omega C_\mu) V_\pi$$

$$I_b = \frac{v_\pi}{r_\pi} + j\omega C_\pi v_\pi + j\omega C_\mu v_\pi$$

$$= \left[\frac{1}{r_\pi} + j\omega (C_\pi + C_\mu)\right] v_\pi$$

$$A_i = \frac{I_c}{I_b} = h_{fe} = \frac{g_m - jwC_M}{\frac{1}{r_\pi} + jw(C_\pi + C_M)}$$

$$\approx \frac{g_m}{\frac{1}{r_\pi} + jw(C_\pi + C_M)}$$

* usually $g_m \gg wC_M$

50mA/V

$2\pi \, 500 \times 10^6 \times 0.05 \times 10^{-12}$

$= \pi \times 5 \times 10^{-5}$

≈ 15.7

$\approx 0.157 \times 10^{-3}$

$$\approx \frac{g_m r_\pi}{1 + jw(C_\pi + C_M) r_\pi}$$

$$\approx \frac{\beta_0}{1 + jw(C_\pi + C_M) r_\pi}$$