Analog Electronic Circuits (UEC301)

By

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THAPAR INSTITUTE
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Subject: Analog Electronic Circuits (UEC301)

Faculty names: (1) Dr. Mayank Kumar Rai (Associate Professor & Course Coordinator)

(Topic of today's Lecture : Multistage Transistor Amplifiers

Key points

- ✓ **Multistage Transistor Amplifier**
- ✓ **Purpose of coupling device**
- ✓ **Types of Coupling**
- ✓ **Important Terms(**Gain, frequency response and bandwidth**)**
- ✓ **R-C Coupled Amplifier**

Contents of this lecture are based on the following books:

- *Jacob Milman & and C.C.Halkias, **"Integrated Electronics Analog and Digital Circuit and Systems"**Second Edition.*
- *Adel S. Sedra & K. C. Smith, **"MicroElectronic Circuits Theory and Application"** Fifth Edition.*
- *Robert L. Boylestad & L. Nashelsky, **"Electronic Devices and Circuit Theory"** Eleventh Edition.*

Multistage Transistor Amplifier

➢ ***A transistor circuit containing more than one stage of amplification is known as multi-stage transistor amplifier.***

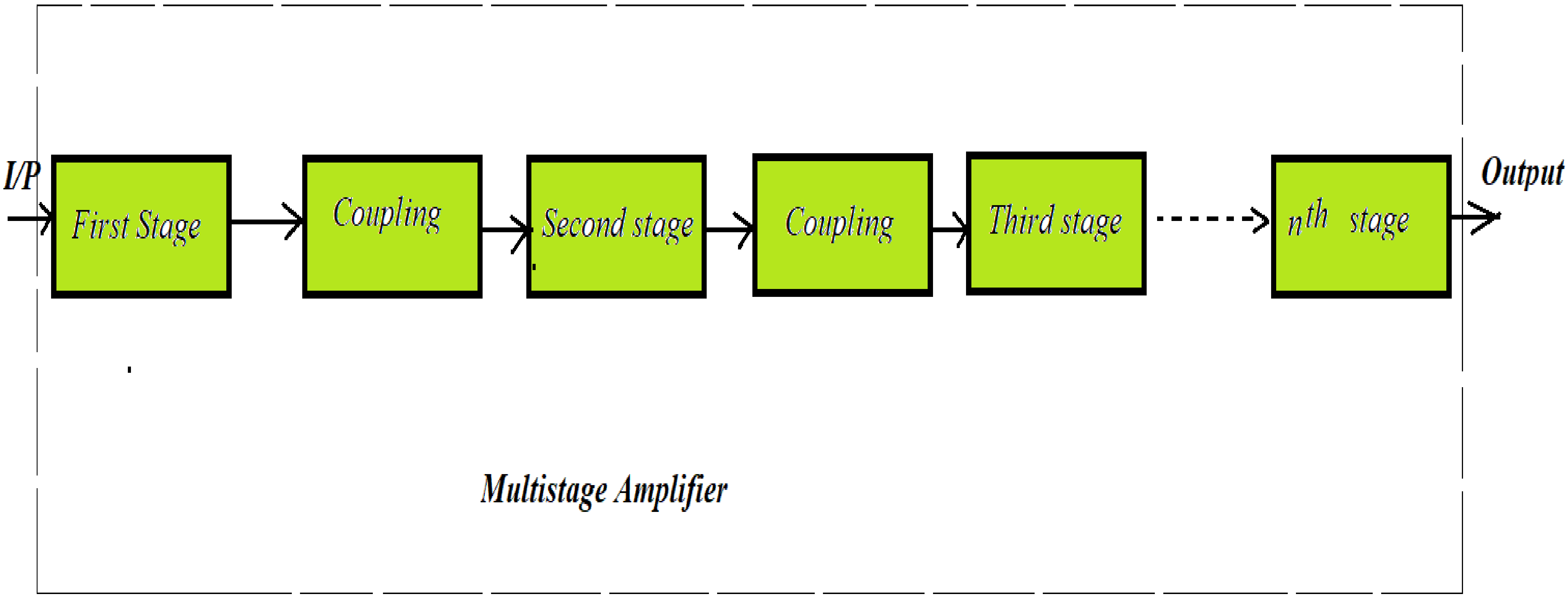


Figure 1: Multistage Amplifier.

Purpose of coupling device

i. Transfer a.c. Output of one stage to the input of the next stage.
ii. Isolate the d.c. Conditions of one stage from the next stage.

Types of Coupling

i. R-C coupling
ii. Transformer coupling
iii. Direct Coupling

Important Terms

i. Gain
ii. Frequency response
iii. Band width

i. <u>Gain</u> The ratio of the output to the input one of the amplifier is called gain.

$$A_V = A_{v1}.A_{v2}.A_{v3}.A_{v4}\ldots.A_{vn}$$

If v_{in} is the input of first stage then
Output of first stage=$A_{v1}v_{in}$
Output of second stage=$(A_{v1}v_{in}).A_{v2}$
Output of third stage=$(A_{v1}.A_{v2}.v_{in})A_{v3}$

Output of nth stage=$(A_{v1}.A_{v2}.A_{v3}\ldots A_{v(n-1)})v_{in}$

ii. Frequency response:

The curves between voltage gain and the signal frequency of an amplifier is known as frequency response.

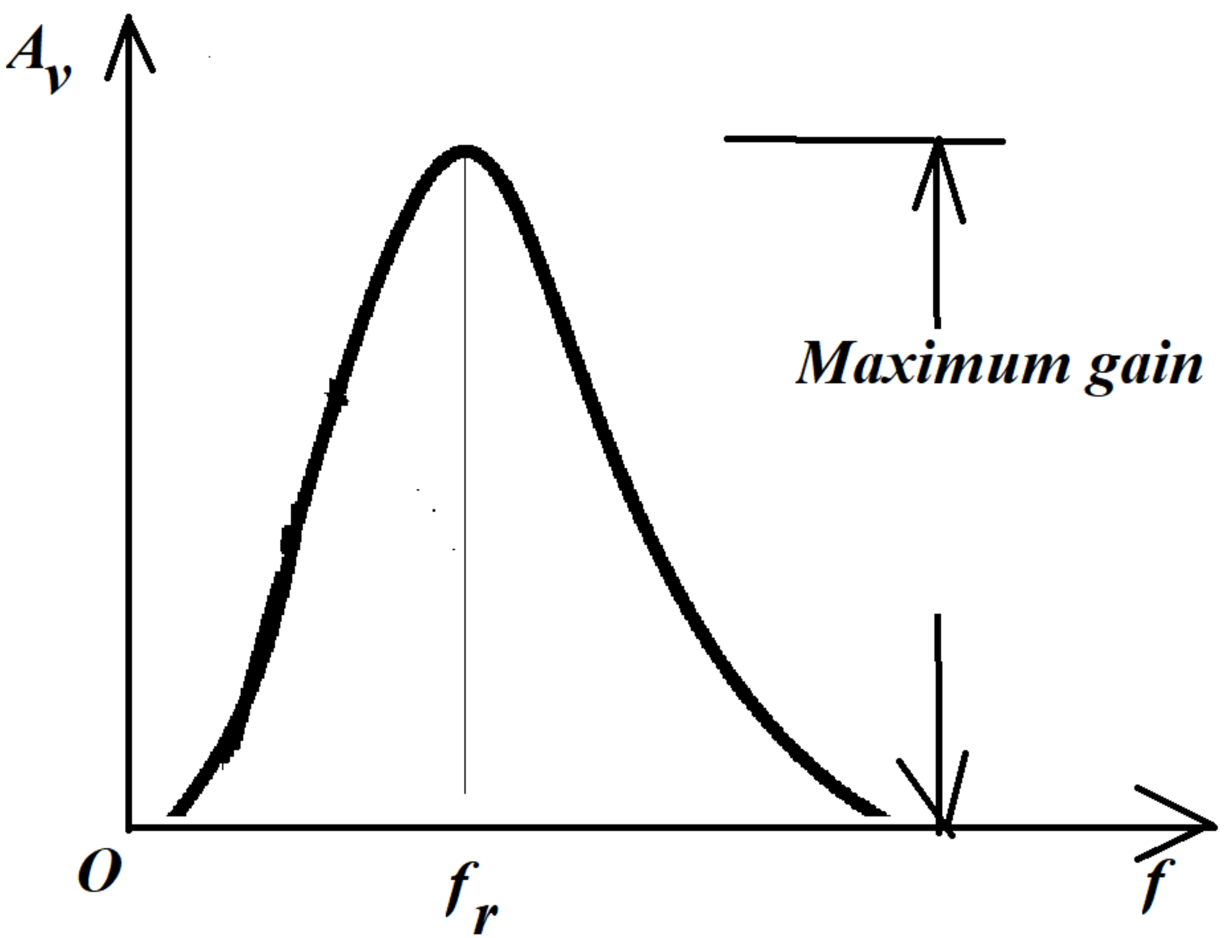


Figure 2: Frequency response.

iii. Band width:

The range of frequency over which the gain is equal to or greater than 70.7% of the maximum gain is known as band width.

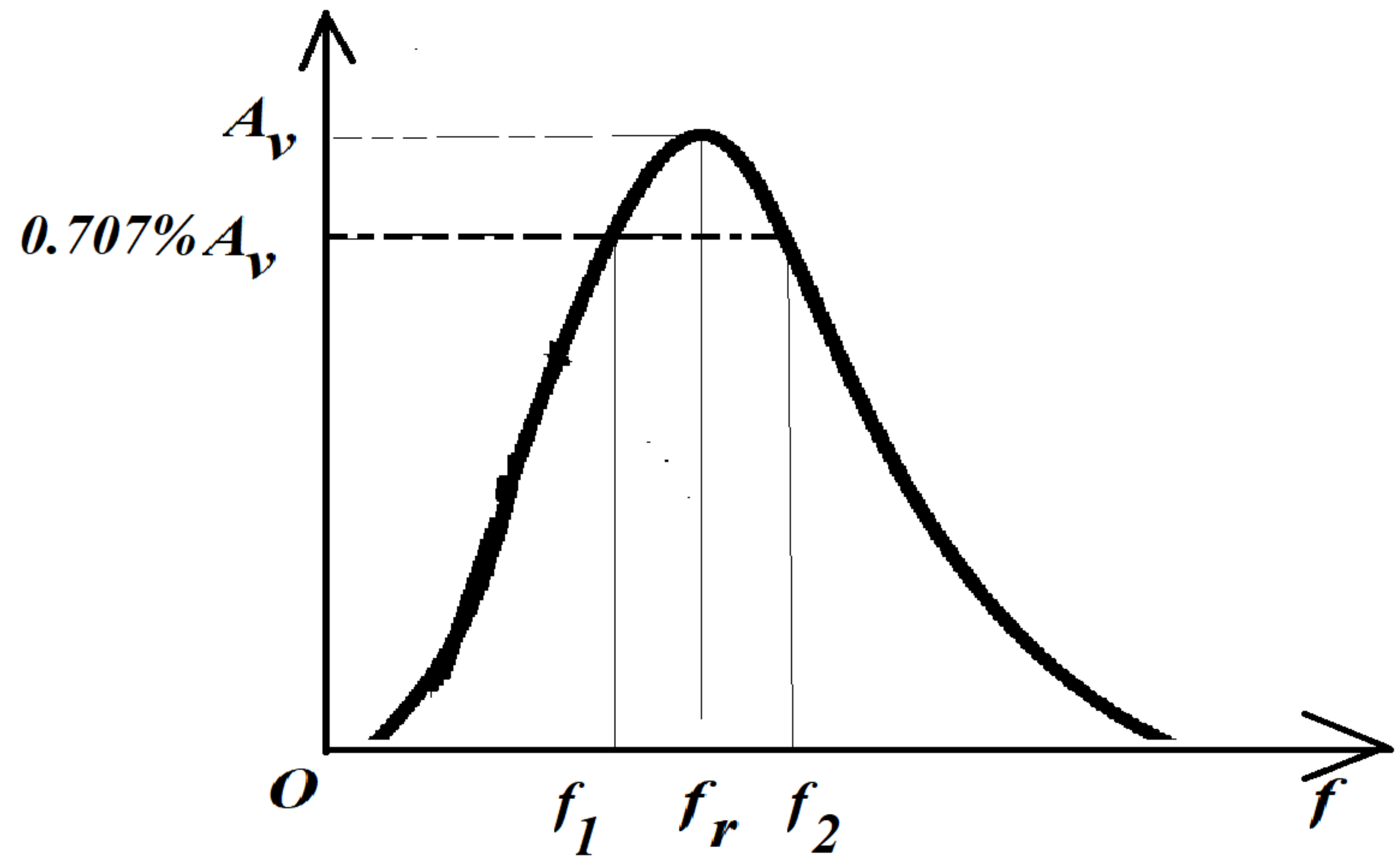


Figure 3: Bandwidth.

R-C Coupled Amplifier

Circuit Details:

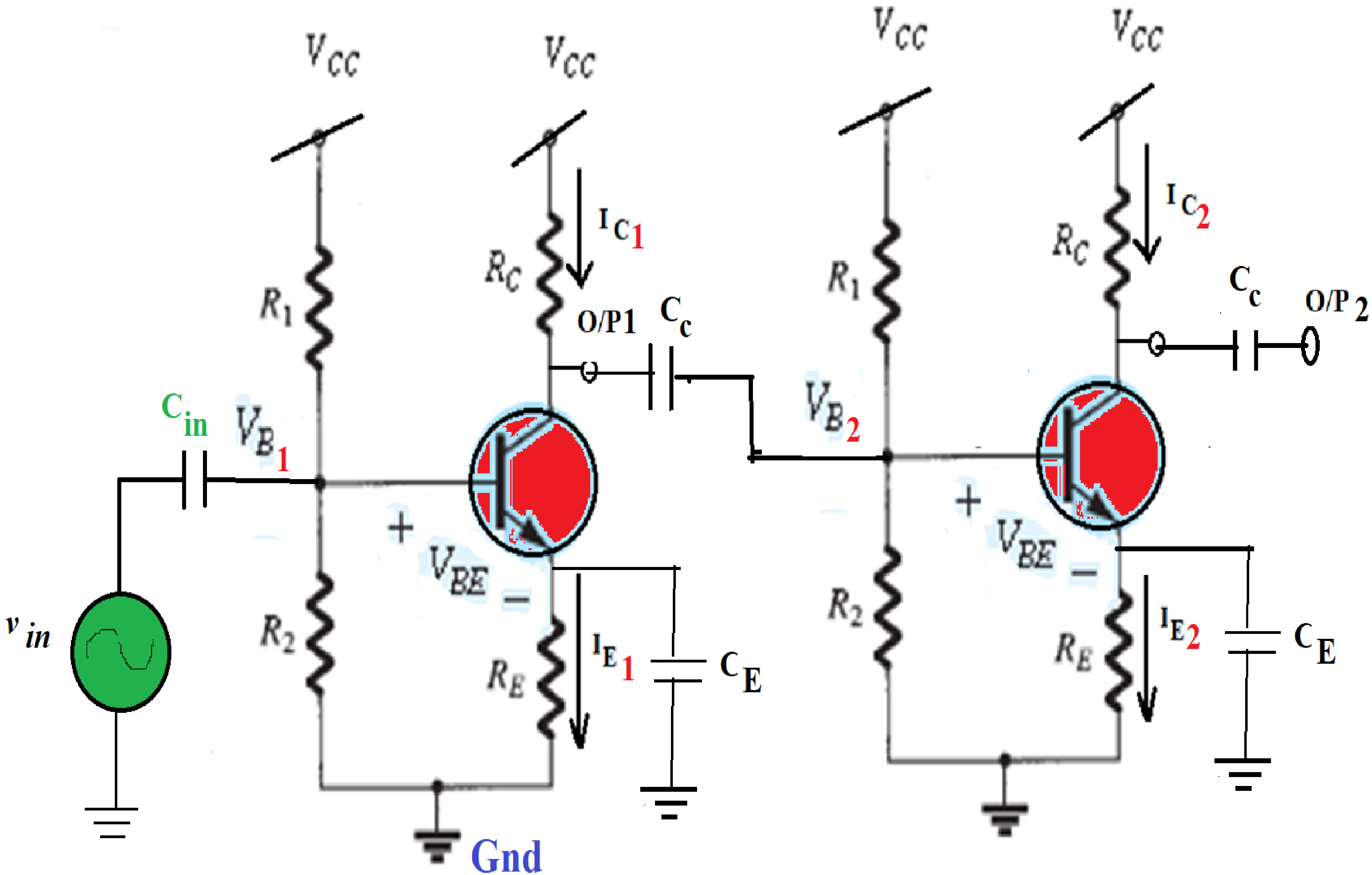


Figure 4: R-C coupled transistor Amplifier.

Operation

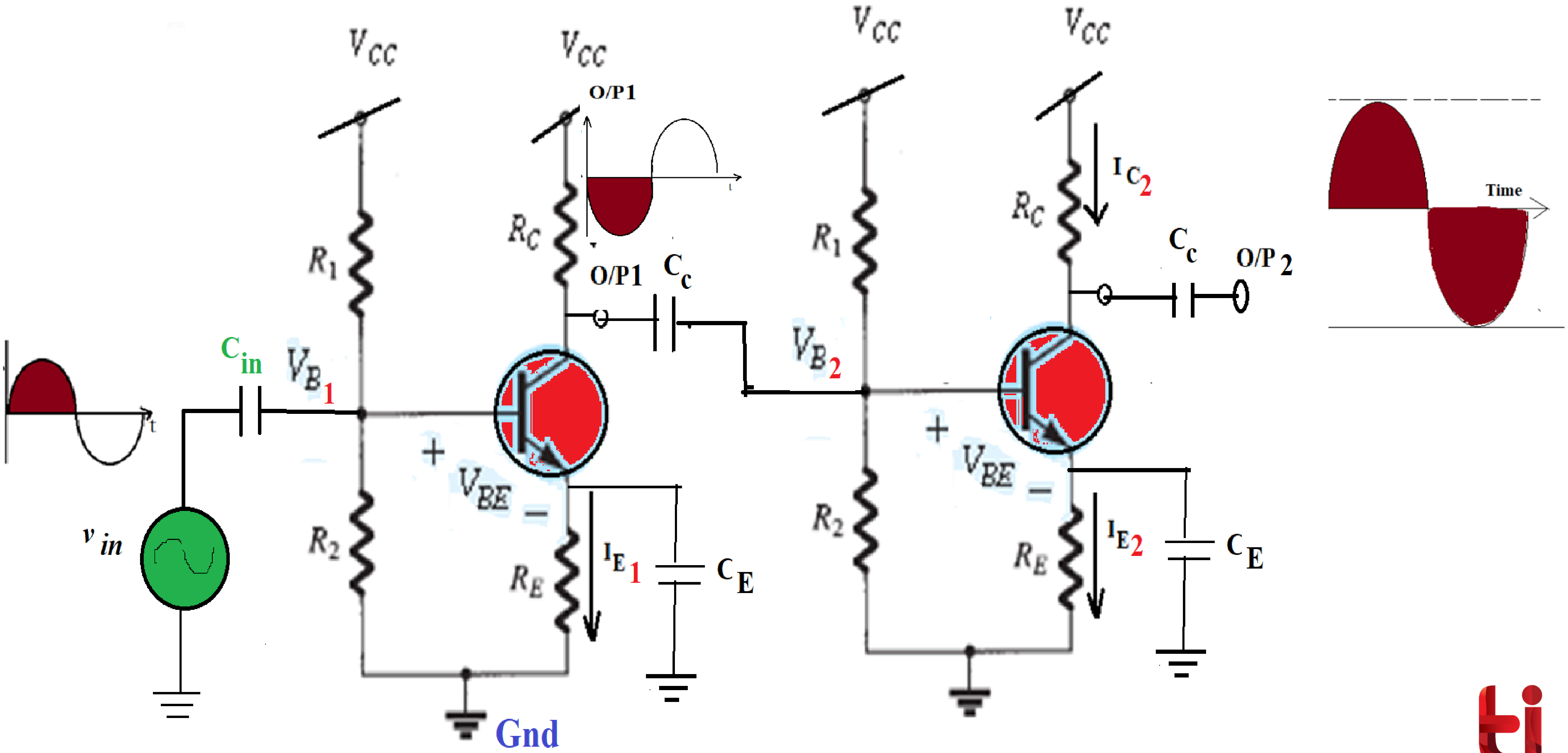


Figure 5: R-C coupled transistor Amplifier with input and output.

Frequency Response:

- <u>At low frequencies(<f1)</u>

$X_{C_C} \uparrow \Rightarrow$ very small part of signal will pass from one stage to the next stage.

- <u>At high frequencies(>f2)</u>

$X_{C_C} \downarrow \Rightarrow$ it behaves as a short circuit

$X_{BE} \downarrow \Rightarrow I_B \uparrow \Rightarrow \beta \downarrow$

- <u>At mid frequencies(f1- f2)</u>

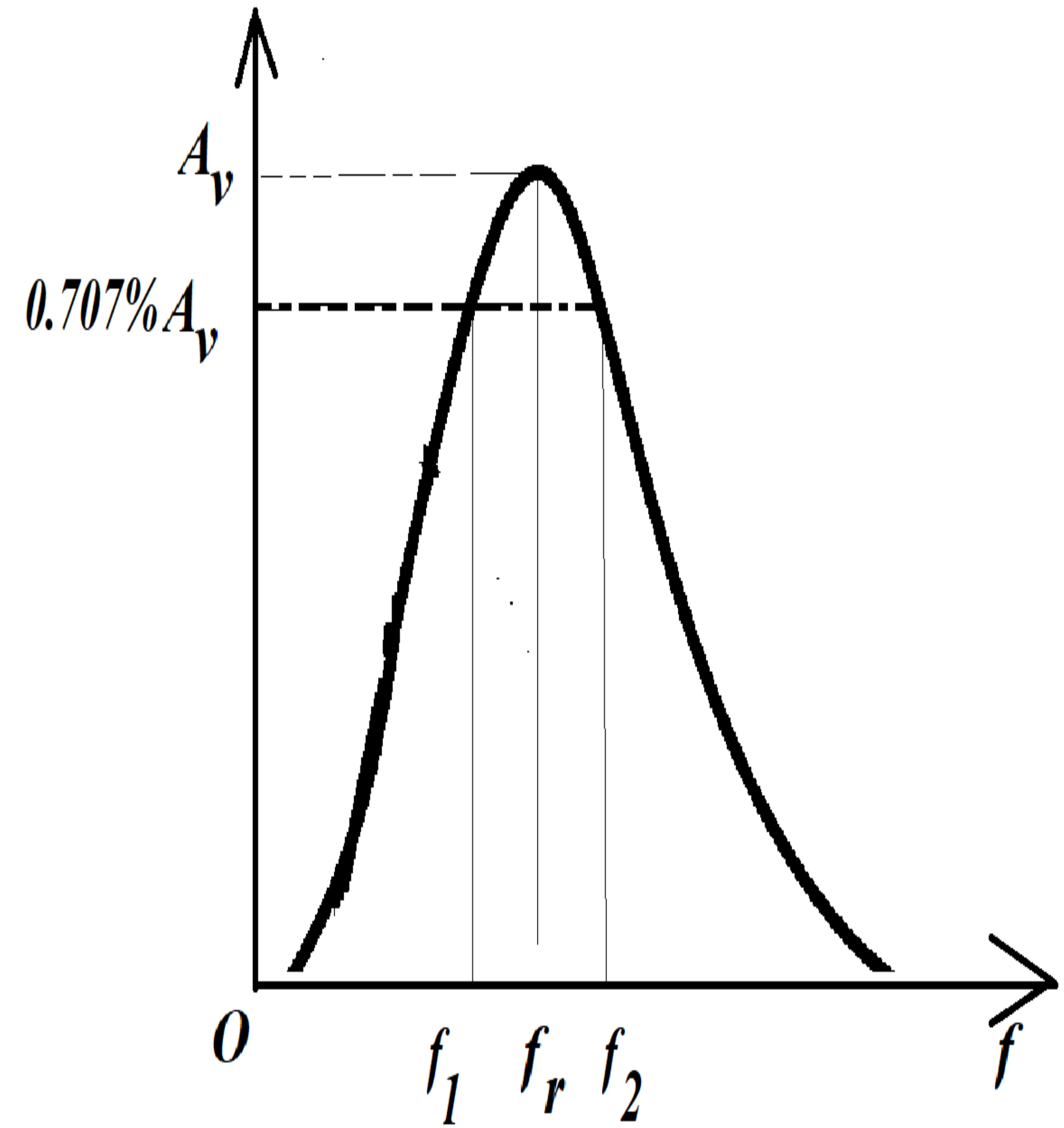


Figure 6: Frequency response of R-C coupled Amplifier.

Low frequency analysis of R-C Coupled Amplifier

$\boxed{A_v = A_1 \times A_2} \rightarrow (1)$

$A_1 = A_{v_1} = \frac{v_{o1}}{v_{in}}$

$A_2 = A_{v_2} = \frac{v_o}{v_{in_2}} = \frac{v_o}{v_{o1}}$

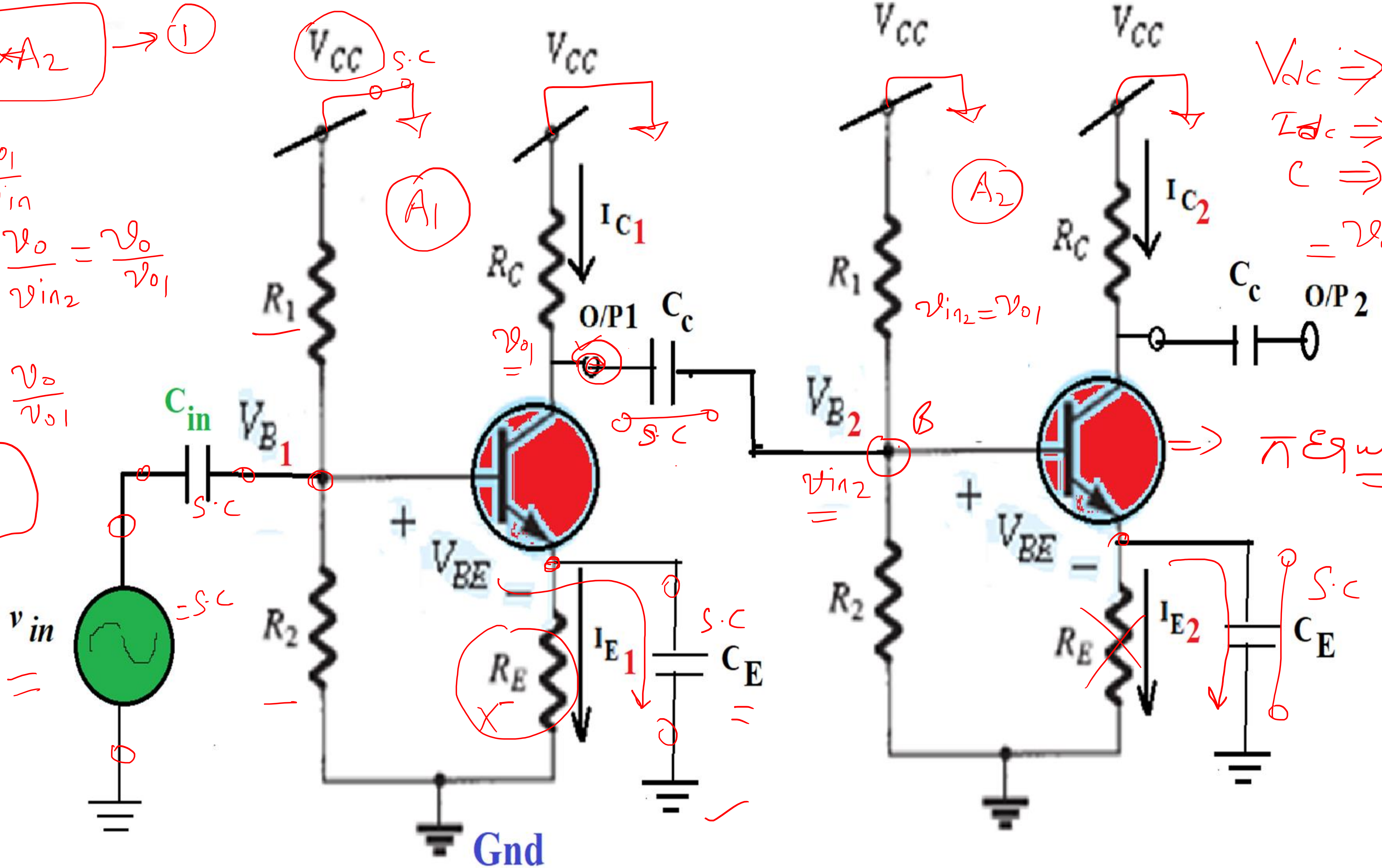
$A_v = \frac{v_{o1}}{v_{in}} \times \frac{v_o}{v_{o1}}$

$\boxed{A_v = \frac{v_o}{v_{in}}}$

$v_{IN} = V_{IN} + v_{in}$

$\Downarrow$

s.c



$V_{dc} \Rightarrow$ s.c

$I_{dc} \Rightarrow$ open

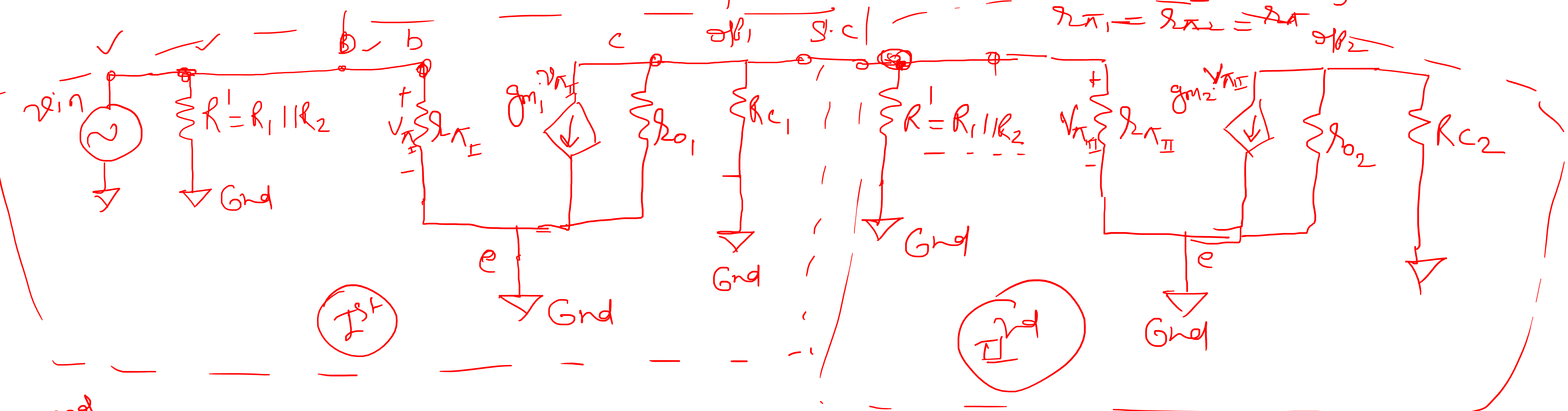
$C \Rightarrow$ s.c

$\Rightarrow \pi$ Equivalent

Small Signal Model of RC Coupled Amp

(Low frequency)

$R_{C_1} = R_{C_2} = R_C$, $r_{o_1} = r_{o_2} = r_o$, $r_{\pi_1} = r_{\pi_2} = r_\pi$



II^{nd}

$A_{v_2} = -g_{m_2} \cdot R_{o_2} \Rightarrow R_{o2} = r_{o_2} \| R_{C_2} \cong R_{C_2}$

$\boxed{A_{v_2} = -g_{m_2} \cdot R_{C_2}} \rightarrow (I)$

$v_{o2} = -g_{m_2} \cdot v_\pi \cdot R_{o_2}$, $v_\pi = v_{o_1}$

$\frac{v_{o2}}{v_{o_1}} = A_{v_2} = -g_{m_2} R_{o2} \cong -g_{m_2} R_{C_2}$

I^{st} stage

$v_{o1} = -g_{m_1} \cdot v_{\pi_1} \cdot R_{o1} \Rightarrow R_{o1} = r_{o_1} \| R_{C_1} \| R'$

$v_{\pi_1} = v_{in} \Rightarrow v_{o1} = -g_{m_1} \cdot v_{in} \cdot R_{o1} \Rightarrow \boxed{\frac{v_{o1}}{v_{in}} = -g_{m_1} \cdot R_{o1} = A_{v_1}} \rightarrow (II)$

$$A_v = Av = Av_1 \cdot Av_2$$

$$= -g_{m1} R_{o1} \{-g_{m2} \cdot R_{o2}\}$$

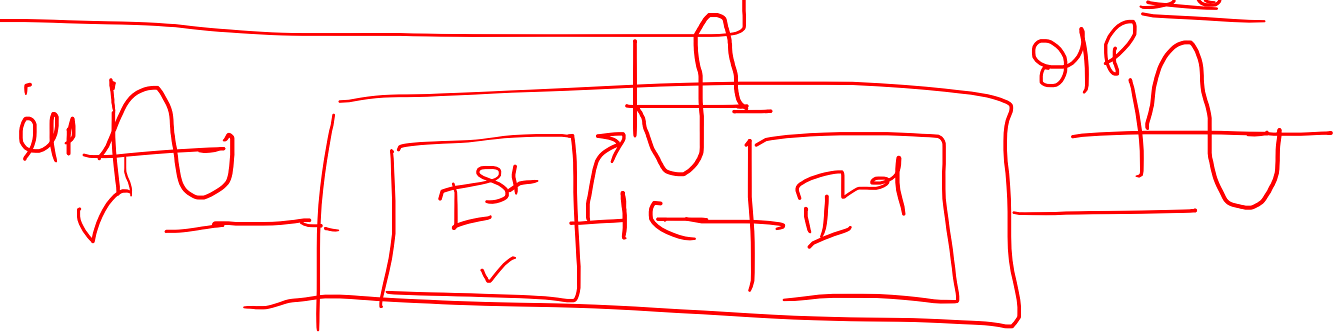
$$\boxed{Av = g_{m1} \cdot g_{m2} \cdot R_{o1} \cdot R_{o2}}$$

$$\left.\begin{matrix} R_{C1} = R_{C2} = R_C \\ r_{o1} = r_{o2} = r_o \end{matrix}\right\}$$

$$\Rightarrow \boxed{A_v = +g_{m1} \cdot g_{m2} \cdot \{r_{o1} \,||\, R_{C1} \,||\, R'\} \cdot \{R_{C2}\}}$$

$\rightarrow$ +ve

360° = 0° phase shift



RC Coupled

R' = i/p bias resistance at IInd stage Amp ckt

$$= R_1 \,||\, R_2 = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

Advantages:

- It has excellent frequency response.
- It has lower cost.

Disadvantages:

- The R-C coupled amplifiers have low voltage and power gain.
- Impedance matching is poor.

Thank You