US03CPHY02

UNIT 2 Small Signal Amplifiers

Part-1

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US03CPHY02 Unit I & II

UNIT- I Transistor Biasing Circuits

Introduction, Need to bias a transistor, Selection of operating point, Need for bias stabilization, Requirement of a biasing circuits, Different biasing circuits, Fixed-bias circuit, Collector to base bias circuit, Voltage divider biasing circuit, Approximate analysis, Accurate analysis, Emitter-bias circuit, PNP transistor biasing circuit, Related numericals

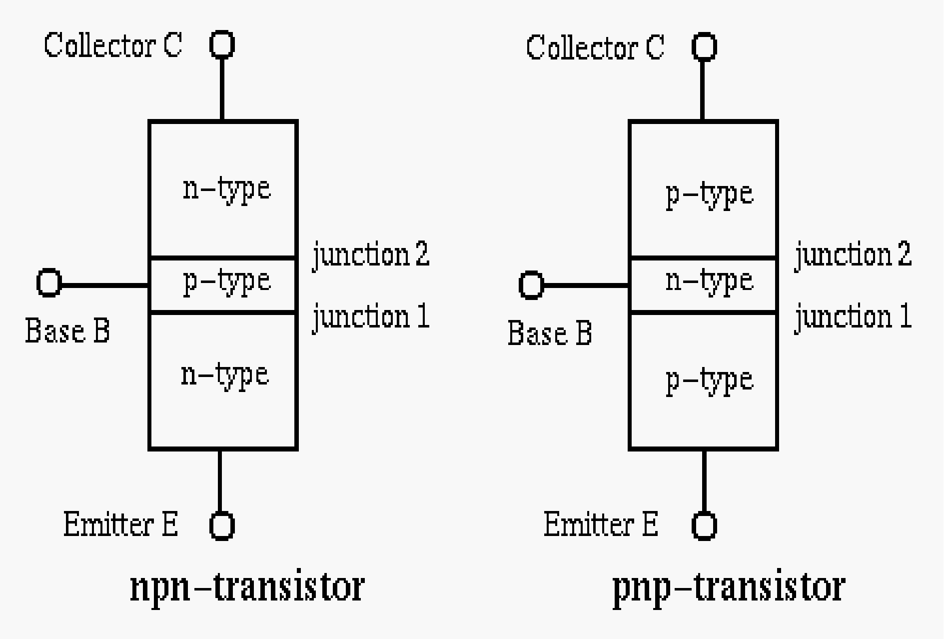
UNIT- II Small Signal Amplifiers and h-parameters

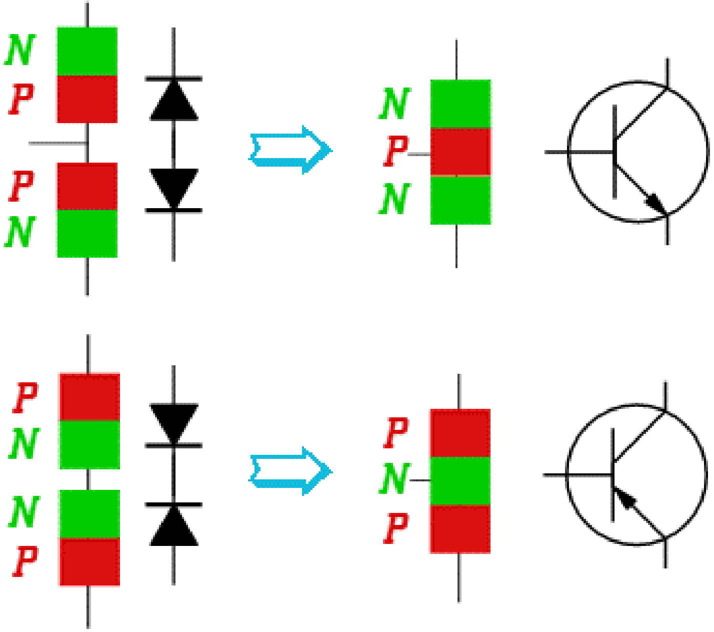
Introduction, Single stage transistor amplifier, Amplifier performance analysis methods, Graphical method, AC and DC load lines, Calculation of gain, Input and output phase relationship, Equivalent circuit method, Development of transistor AC equivalent circuit, h-parameter equivalent circuit, Amplifier analysis, Need of multistage amplifier, Gain of multistage amplifier, Related numericals

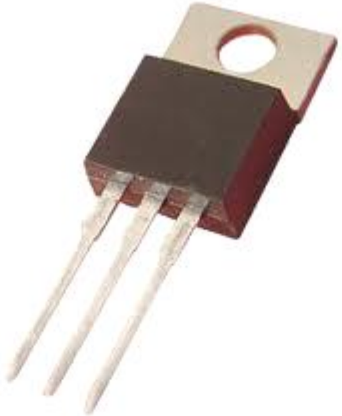
So far you have studied the ….

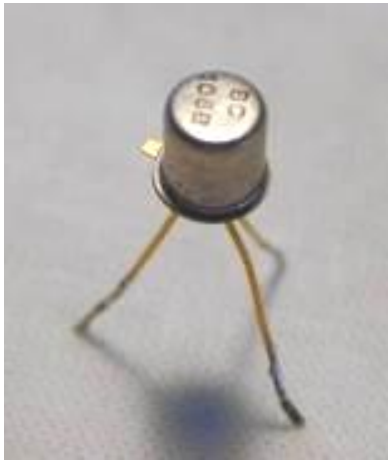
- Transistor Structure: PNP & NPN
- Transistor Operation modes: CB,CC and CE
- Transistor Characteristics : Input and Output
- Operating Point : (I_B, I_C, V_{CE})
- Biasing Circuits: Fixed Bias, C to B Bias, Voltage Divider Biasing & Emitter Bias Circuit.

Transistor Structure



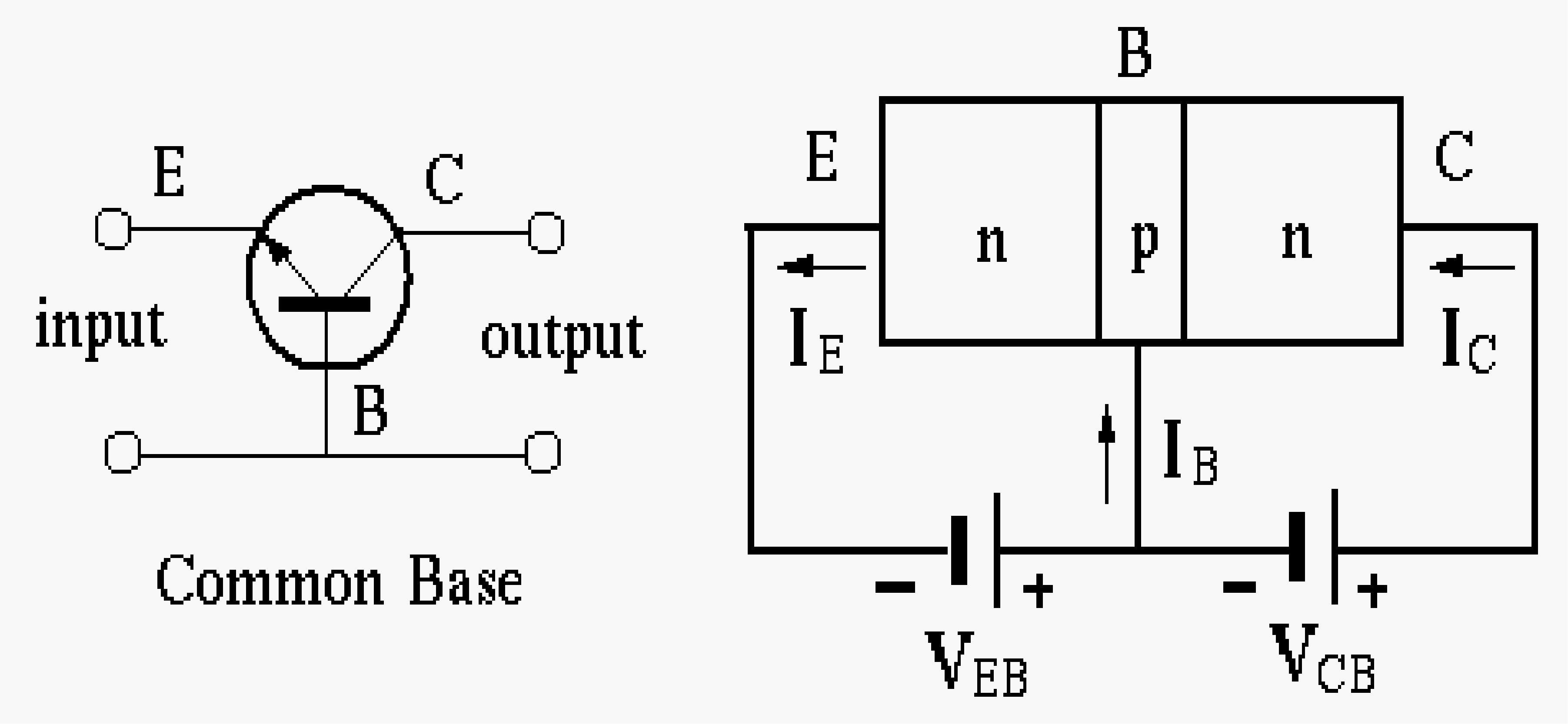






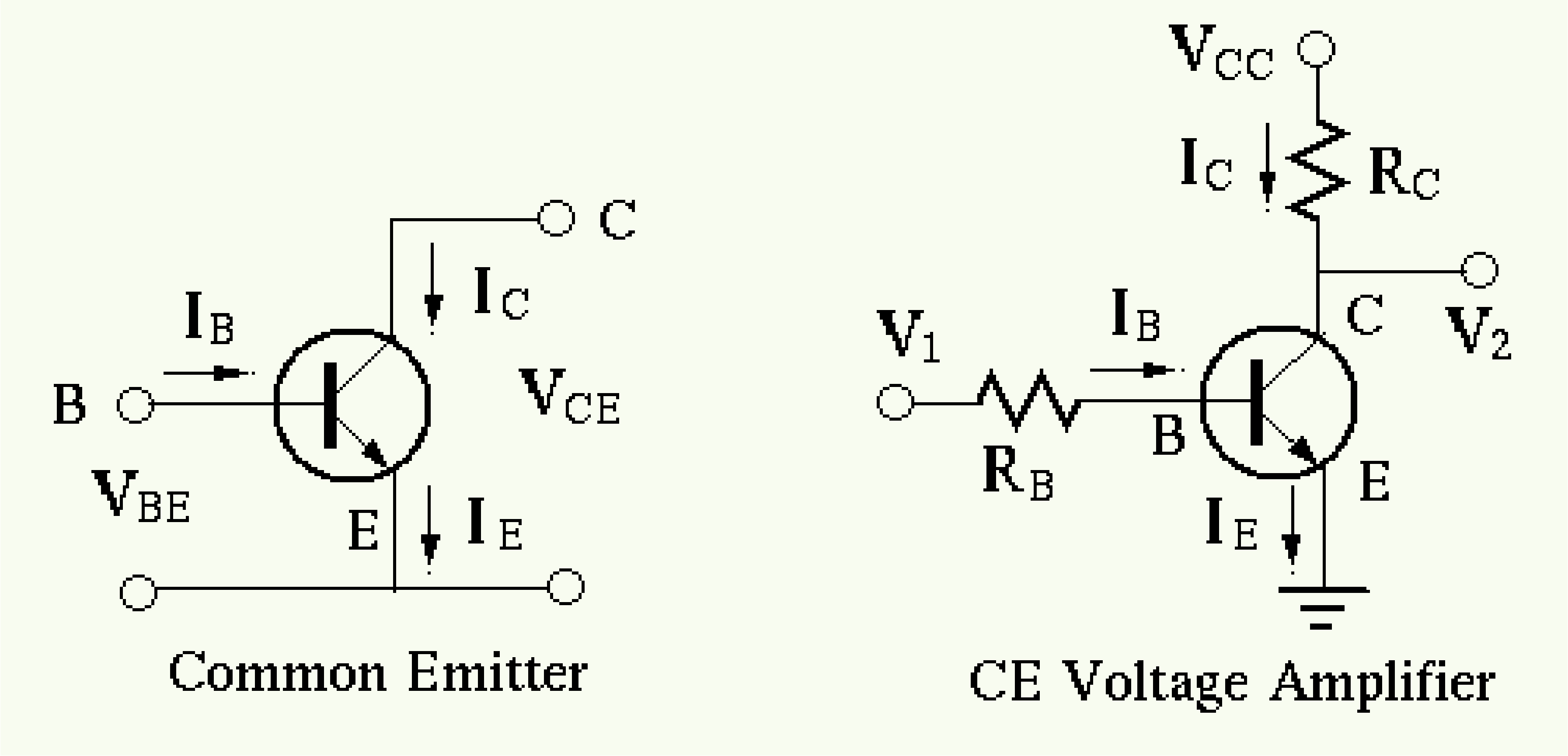
Transistor Operational Modes

Common Base (CB)



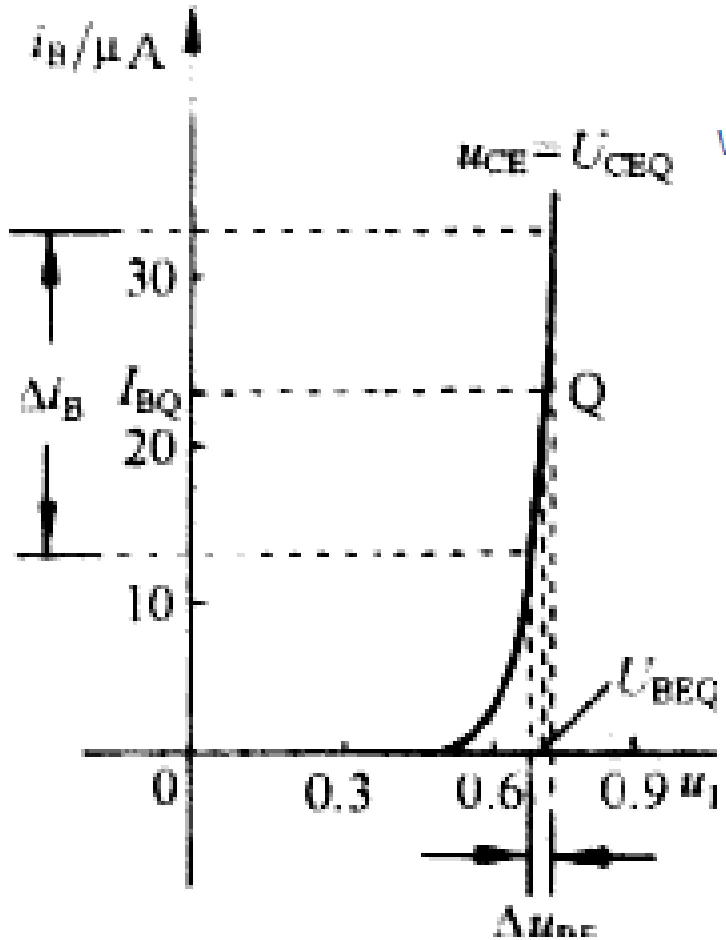
Transistor Operational Modes

Common Emitter (CE)

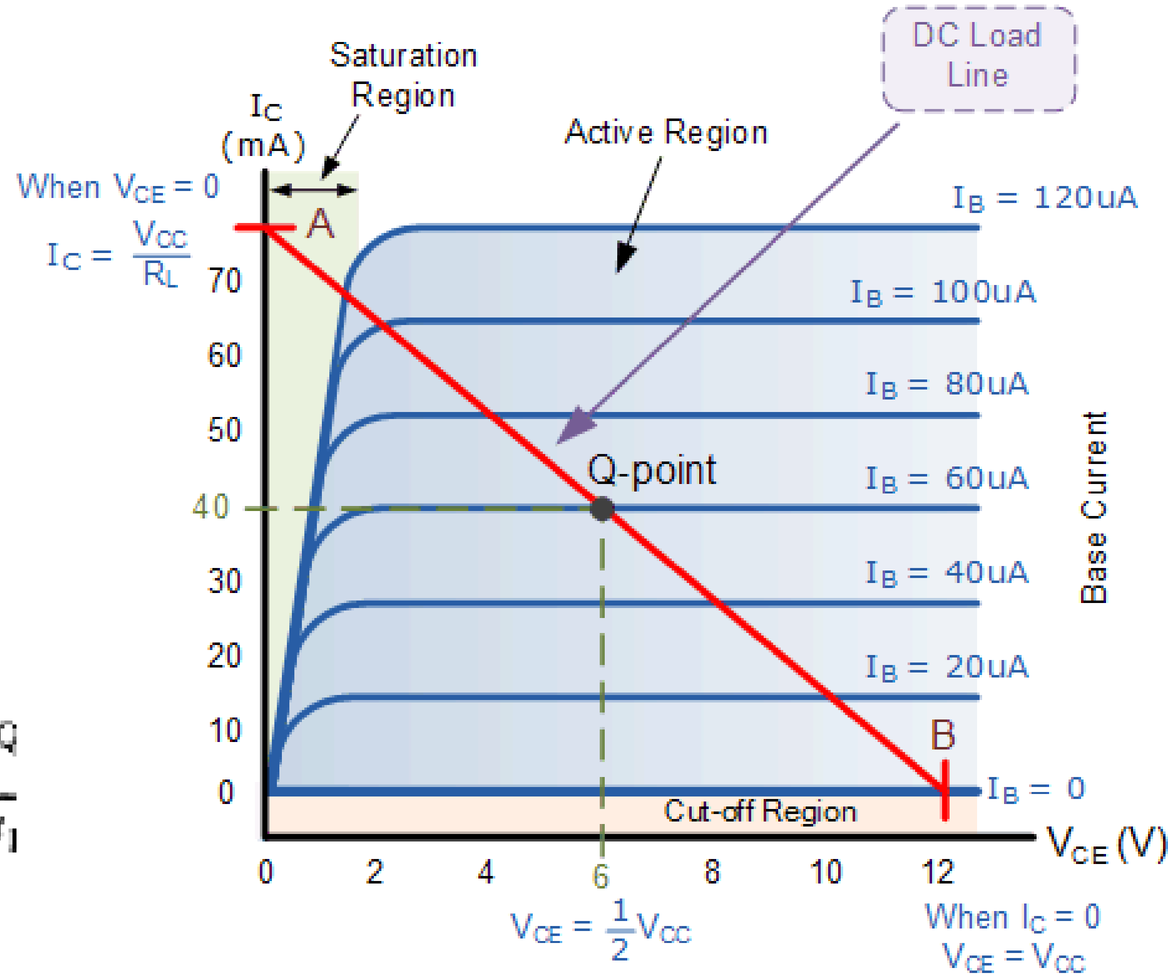


CC Mode – assignment!

CE Transistor Characteristics

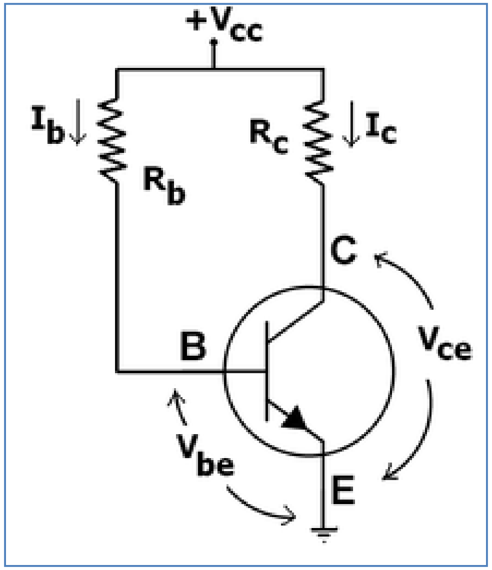


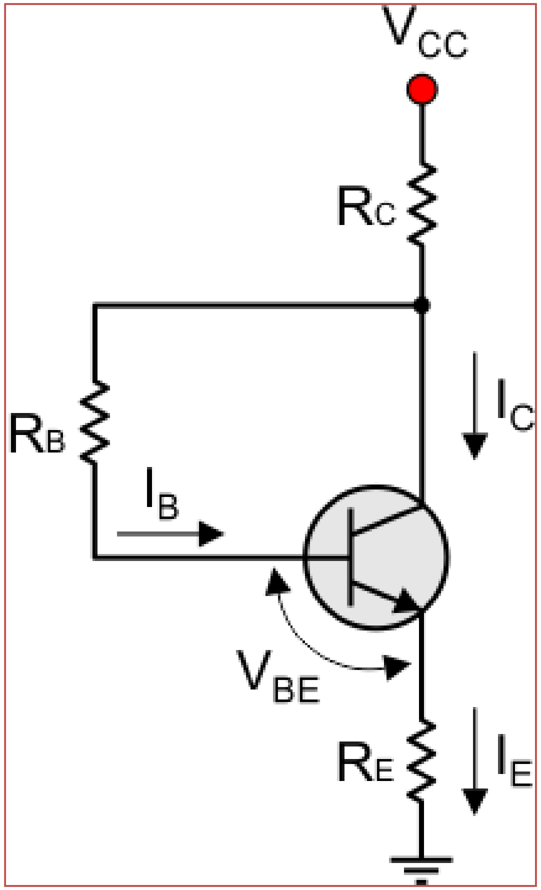
Input Characteristics

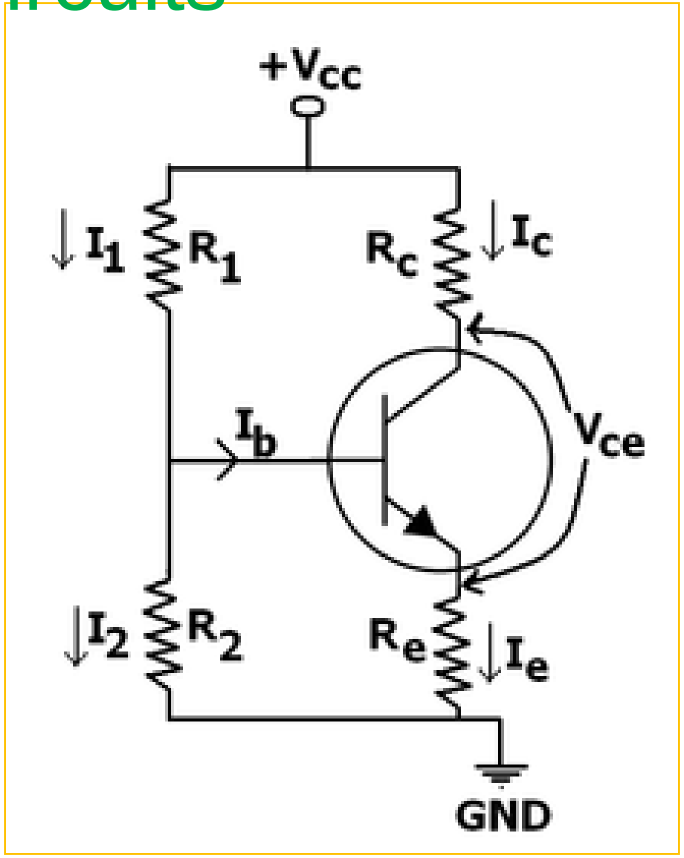


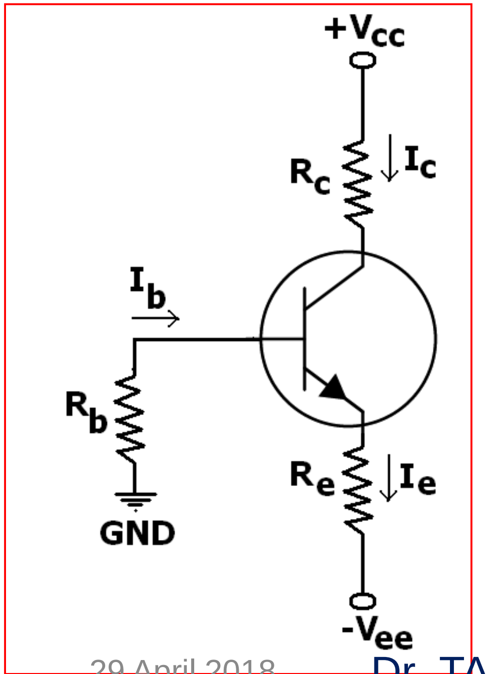
Output Characteristics

Transistor Biasing Circuits









Now, from here, ahead…

- Small Signal Amplifier
- Graphical Method
- Equivalent Circuit Method
- h-Parameters: Transistor as a Two-Port System
- h-Parameter Equivalent Circuit of a Transistor
- h-Parameter: Determination for CE Transistor
- CE Amplifier: Analysis using h-parameters
- Example:
- Multi-stage Amplifiers

What are Small Signal Amplifiers ?

When variation of output (i_c) with input (i_b) are not very large the amplifier is called: *Small Signal Amplifier.*

Applicatio

Radio &T

Tap Recor

Stereos

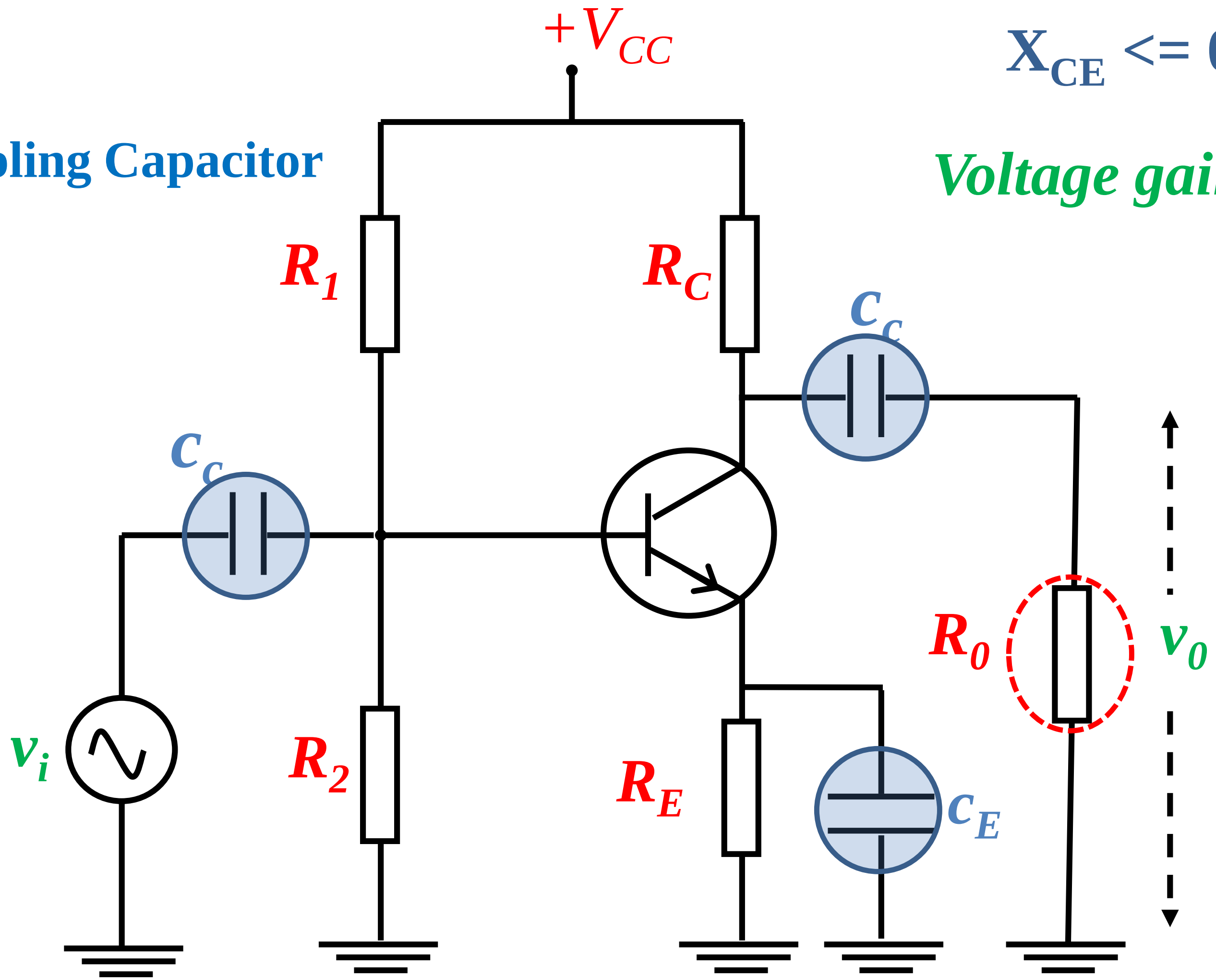
Measuring instruments

Single Stage Transistor Amplifier
Voltage divider biasing circuit

C_C:Coupling Capacitor

$X_{CE} <= 0.1R_E$

Voltage gain $A_v = V_o / V_i$



Small Signal Amplifier Analysis: why ?

The following parameters of amplifier are used to describe the performance of the circuit.

1. Input Impedance (Z_i)
2. Output Impedance (Z_0)
3. Current Gain (A_i)
4. Voltage Gain (A_v) and
5. Bandwidth

The transistor circuits needs to be analyzed to determine the values of these parameters.

Small Signal Amplifier: Analysis

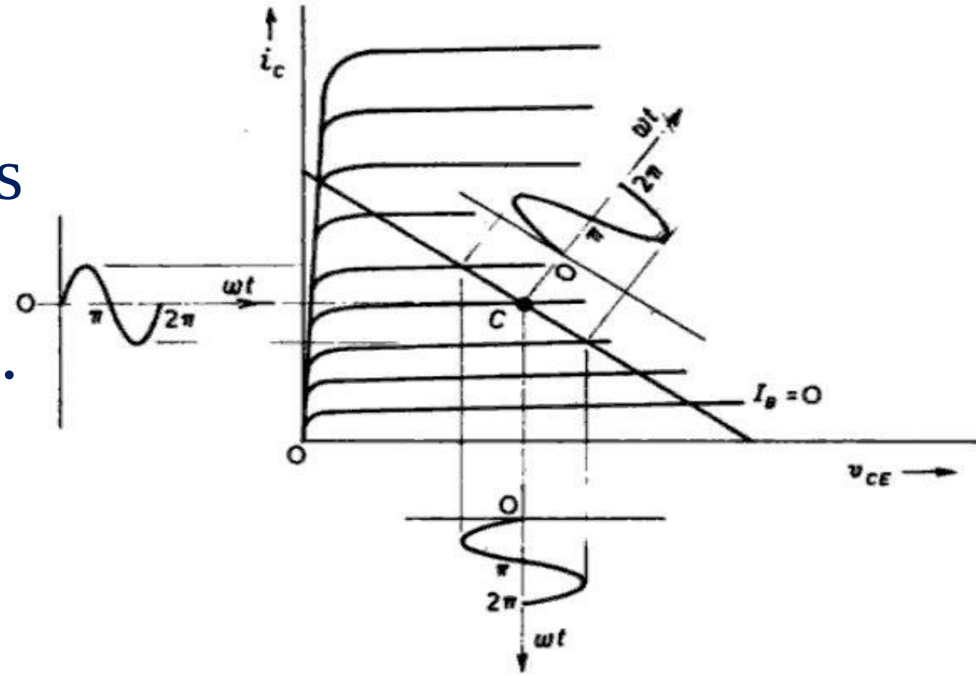
1. Graphical Method.
2. Equivalent Circuit Method.

Graphical Method for Amplifier Analysis

Advantages:

- No approximate assumptions.
- More accurate results than other methods.
- Only method suitable for large signal amplifiers and power amplifiers.

We need output characteristics supplied by manufacturer to see variations of I_B, Ic and V_C.



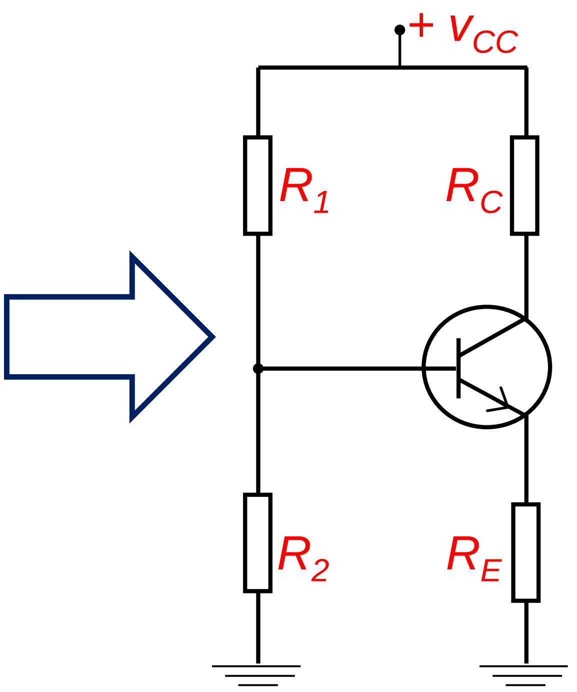
Graphical Method for Amplifier Analysis

The method involves the determination of;

1. DC Load Line (DC Analysis)
2. AC Load Line (AC Analysis)
3. Current Gain
4. Voltage gain
5. Phase Relations

Graphical Method: DC Analysis (DC Load Line)

Are DC and AC Load Lines same or different ?

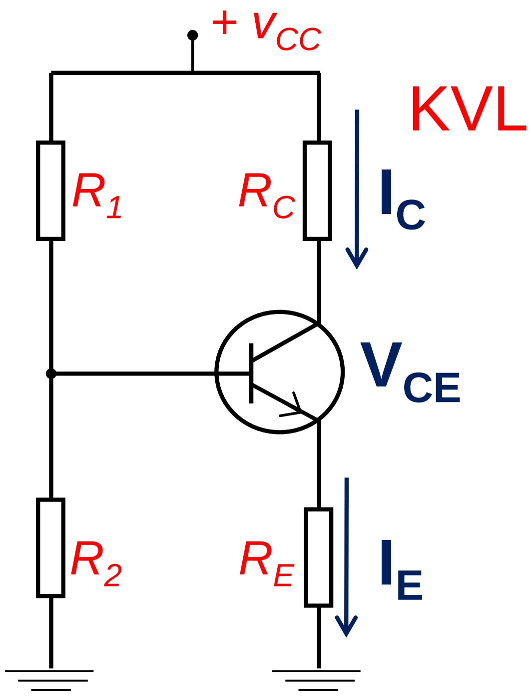


DC behavior

For all DC currents or voltages all Cs make open circuit.

Graphical Method: DC Analysis

DC load line:



DC behavior

$$V_{CC} = I_C R_C + V_{CE} + I_E R_E$$

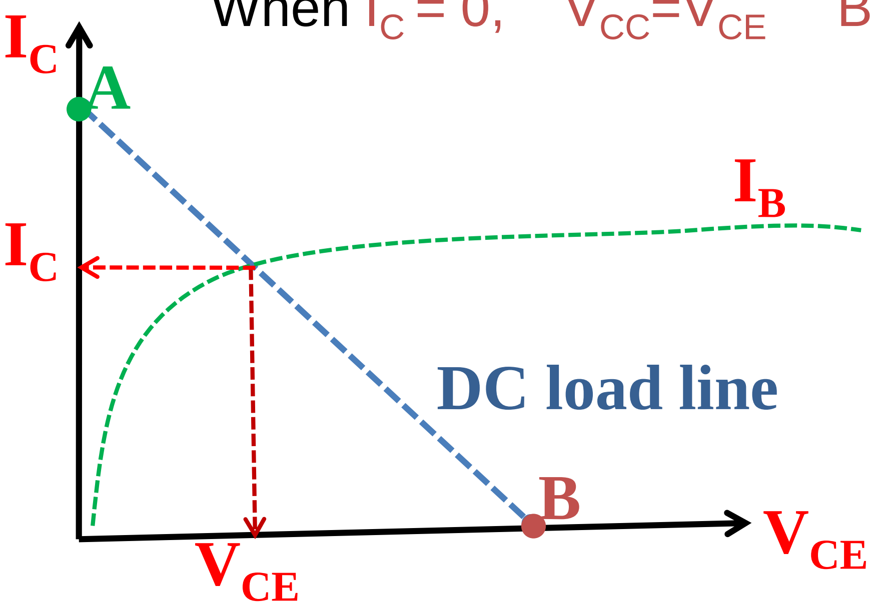
$$\therefore V_{CC} = I_C R_C + V_{CE} + I_C R_E$$

$$\therefore I_C = \frac{-1}{(R_C + R_E)} V_{CE} + \frac{V_{CC}}{(R_C + R_E)}$$

y = m x + c

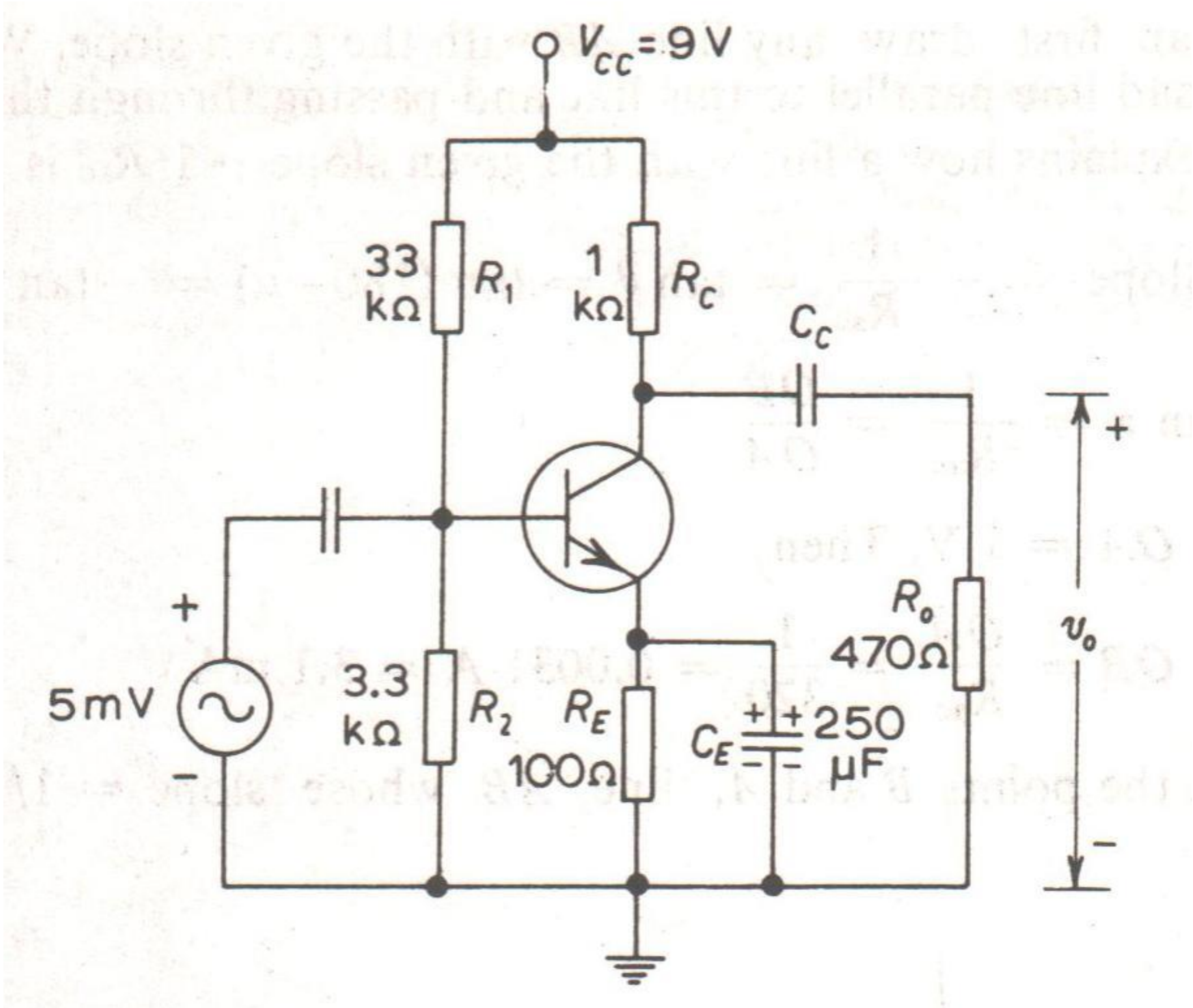
When $V_{CE} = 0$, $I_C = V_{CC} /(R_C+R_E)$ A

When $I_C = 0$, $V_{CC}=V_{CE}$ B

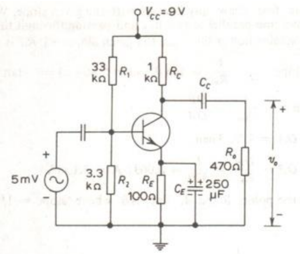


Graphical Method: DC Analysis

Determination of DC load line; Example:



Graphical Method: DC Analysis



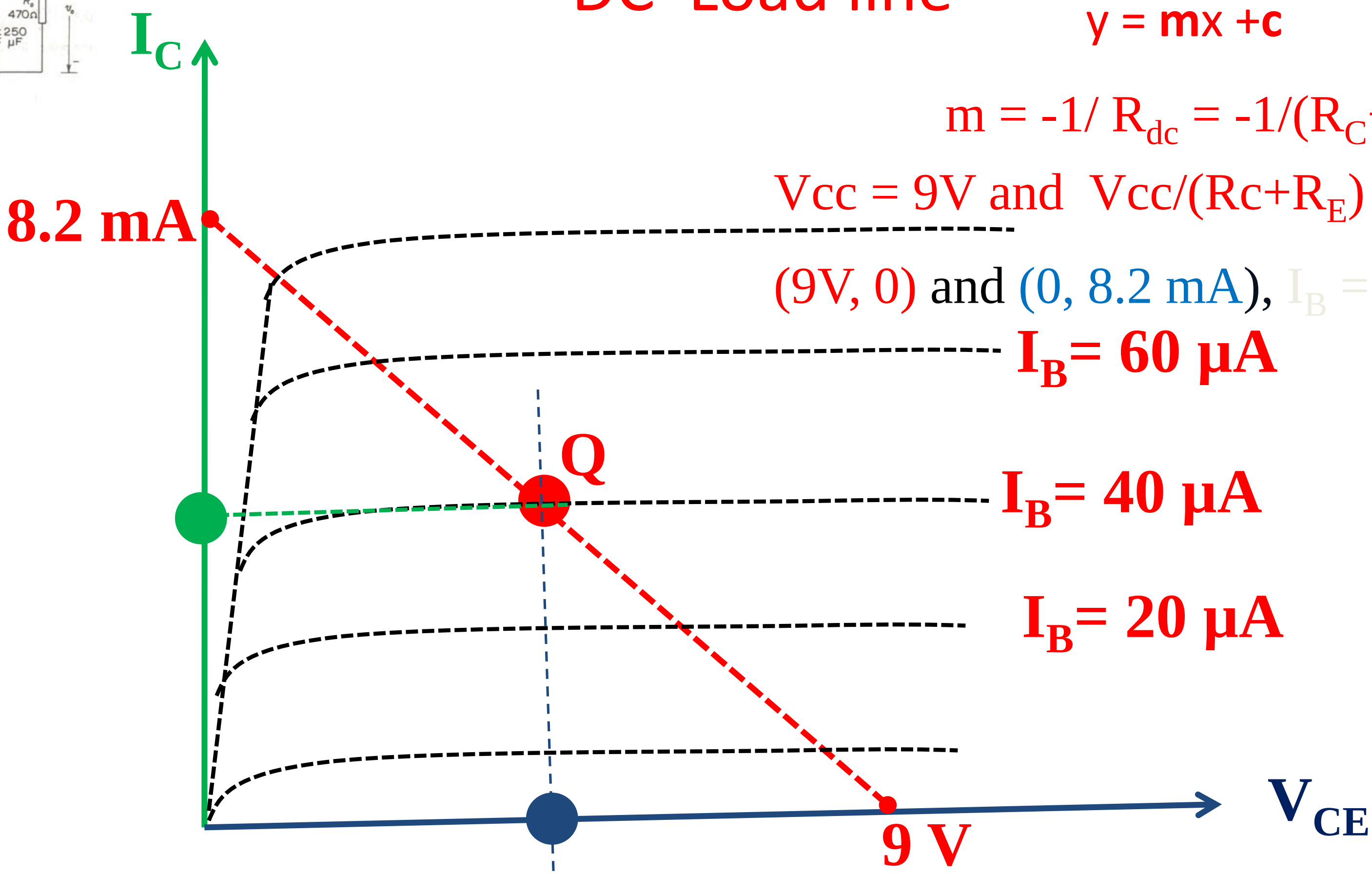
DC Load line

y = mx +c

$m = -1/R_{dc} = -1/(R_C+R_E)$

V_{cc} = 9V and $V_{cc}/(R_c+R_E)$ = 8.2 mA

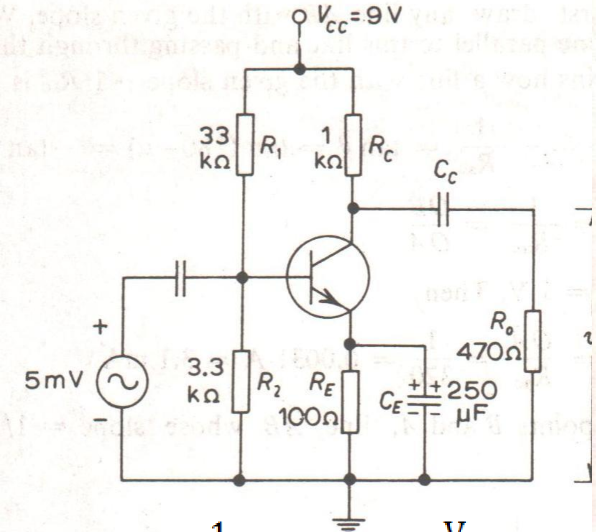
(9V, 0) and (0, 8.2 mA), I_B =30 µA



$$\therefore\ I_C = \frac{-1}{(R_C + R_E)} V_{CE} + \frac{V_{CC}}{(R_C + R_E)}$$

Graphical Method: DC Analysis

Determination of DC load line; Example:



$$\therefore\ I_C = \frac{-1}{(R_C + R_E)} V_{CE} + \frac{V_{CC}}{(R_C + R_E)}$$

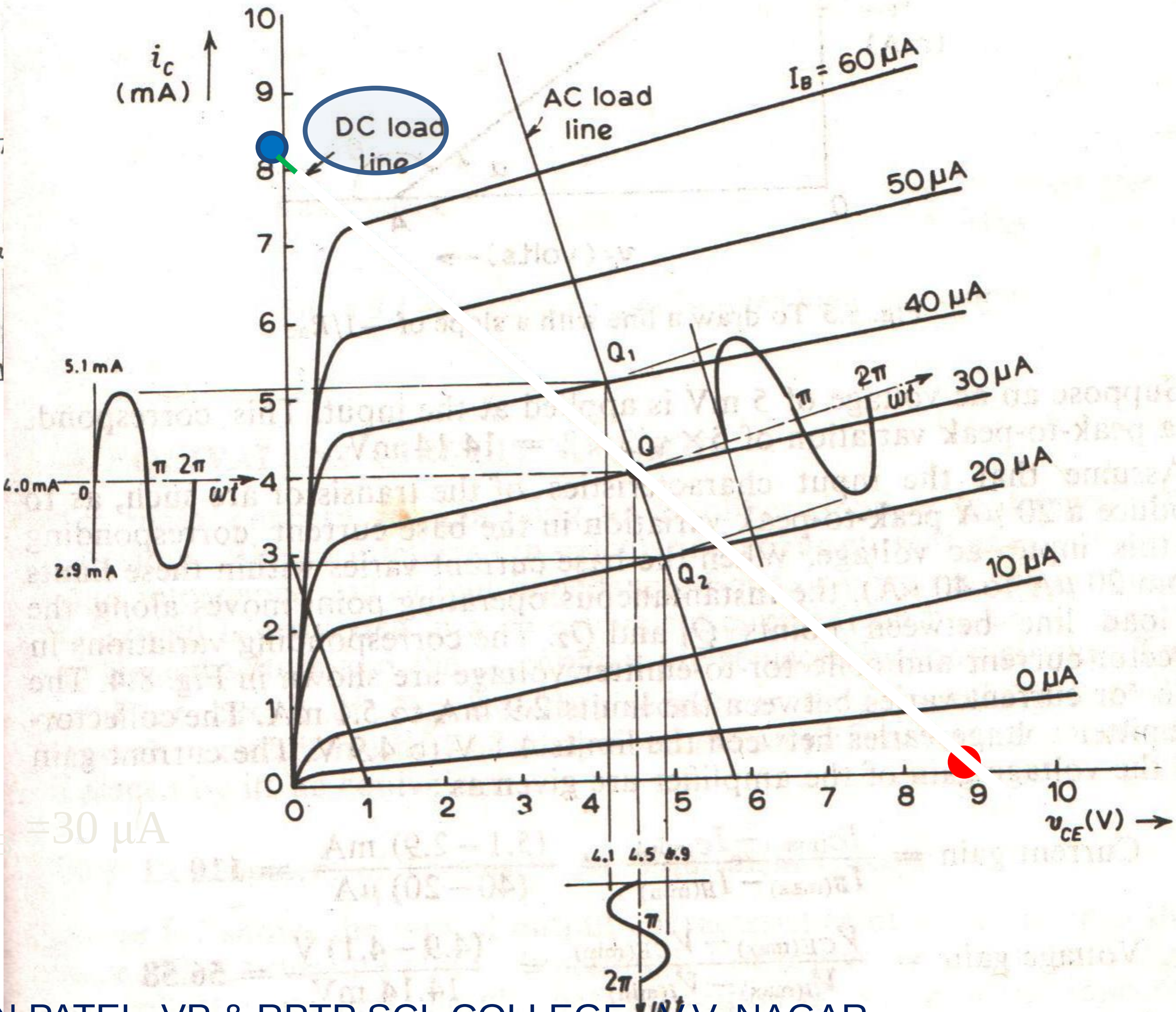
y = **mx +c**

$m = -1/ R_{dc} = -1/(R_C+R_E)$

Vcc = 9V and

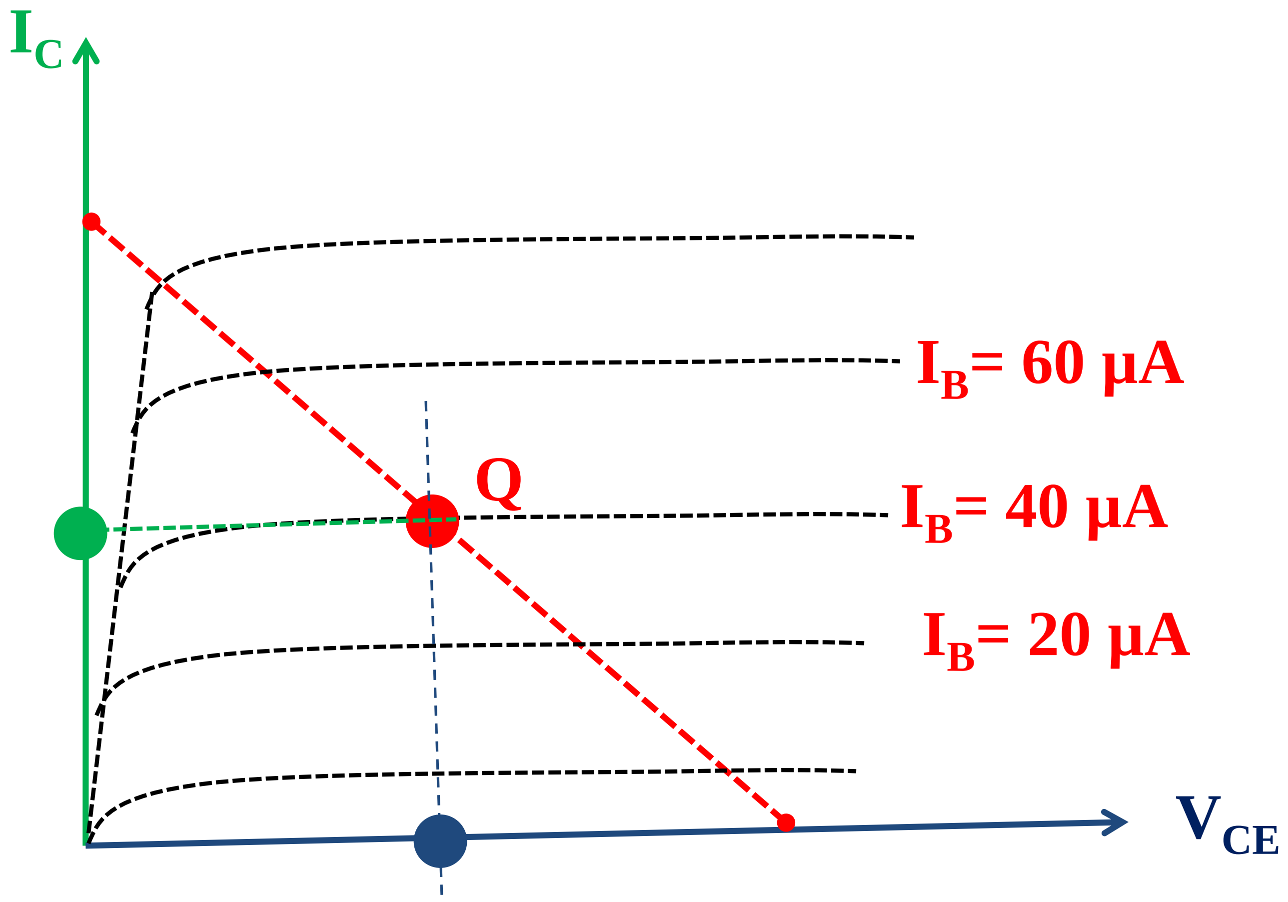
$Vcc/(Rc+R_E) = 8.2$ mA

(9V, 0) and (0, 8.2 mA), I_B =30 μA



Graphical Method: DC Analysis

DC Load line Variations in Q with DC bias (I_B)



But with AC signal, changes in Q are very fast.

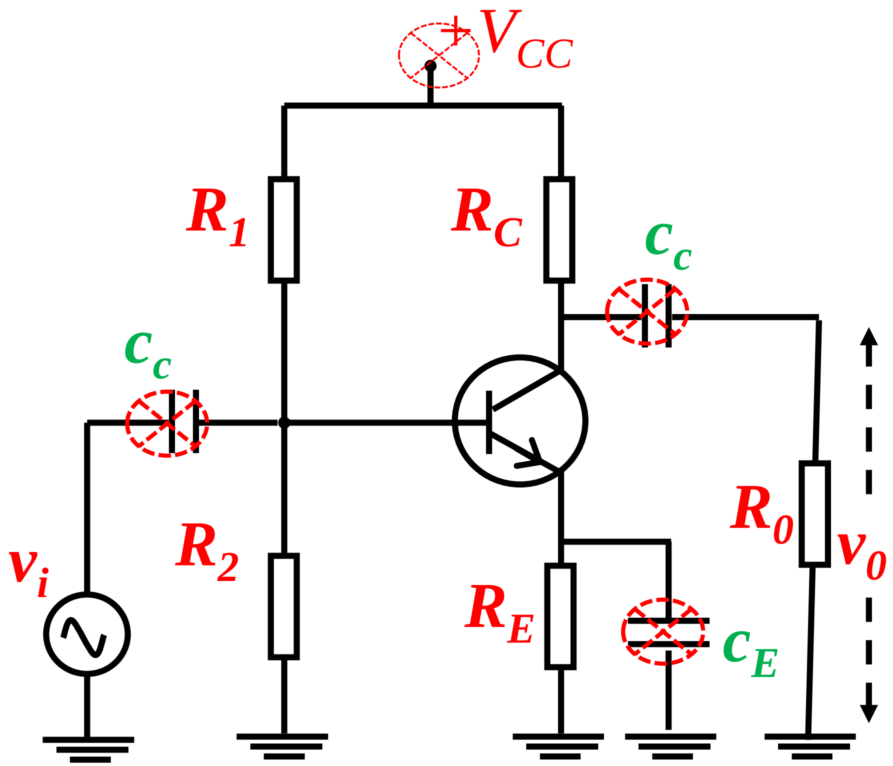
Graphical Method: AC Analysis

We need two Considerations:

1. The capacitive reactance is $X_c = 1/(2\pi fC)$ Ω. It indicates that the coupling & emitter by-pass capacitor can be approximated as short circuit at high enough frequency.
2. Since, we deal with only ac voltages we do need not to consider effect of dc voltages/currents in the circuit.

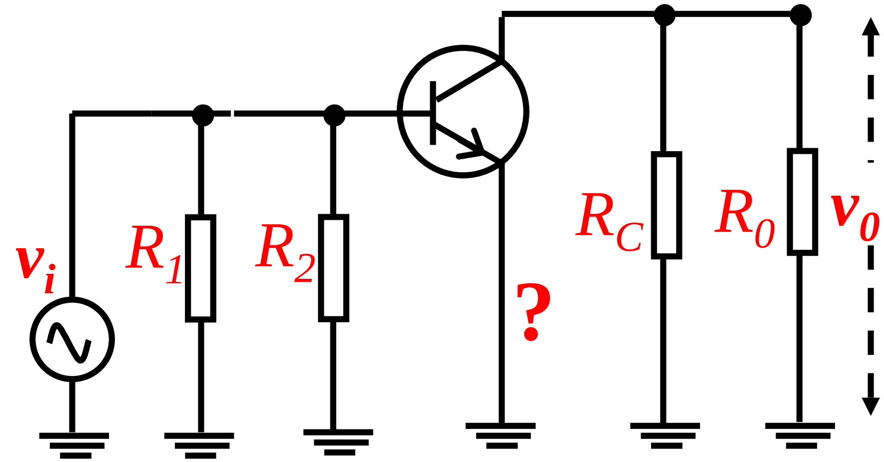
With these two considerations the amplifier circuit can be modeled for equivalent circuit.

Graphical Method: AC Analysis



Basic CE Circuit

1. Effect of Cc's and C_E
2. DC supply Shorted

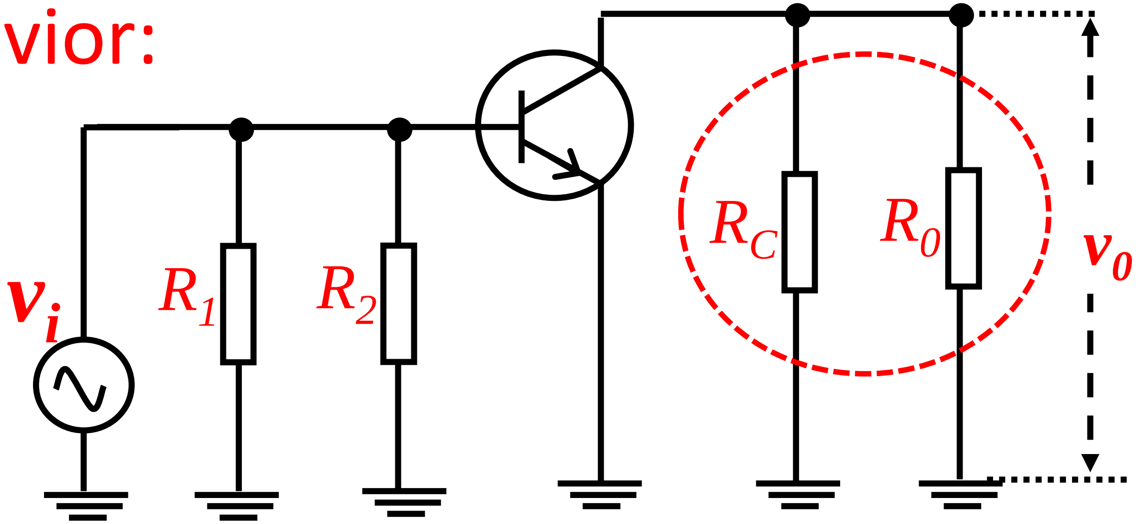


AC behavior

Where is R_E?

Graphical Method: AC Analysis

AC behavior:



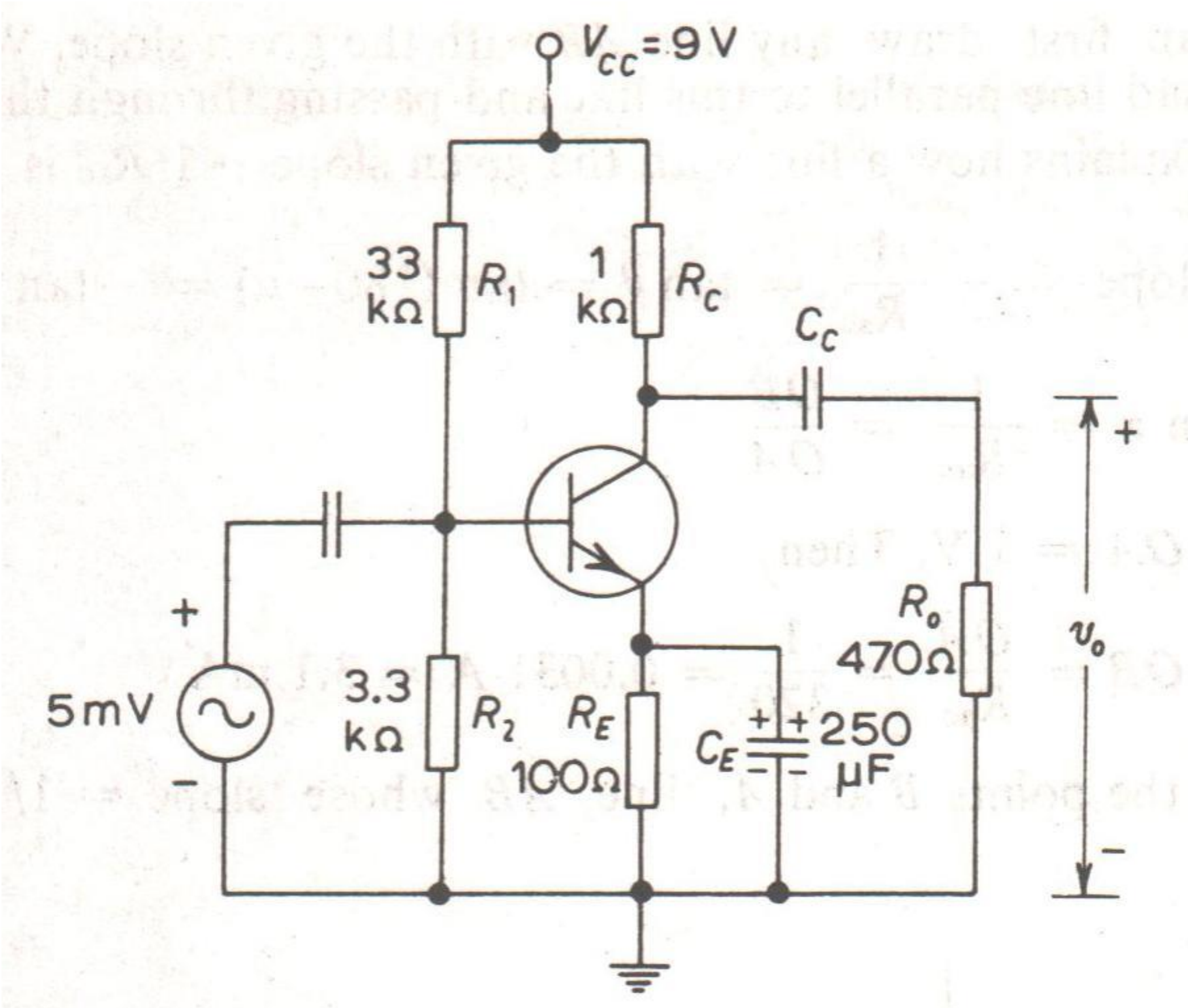
As shown, R_C and Ro in parallel forms the ac load R_{ac} .

The load line corresponding to this R_{ac} is ac load line

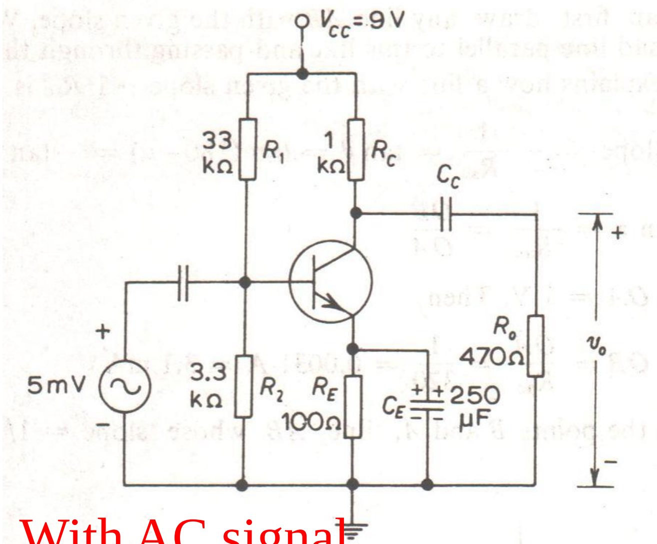
Since R_{dc} and R_{ac} are different, DC and AC *load lines are different.* However both must passes through Q point for zero signal condition.

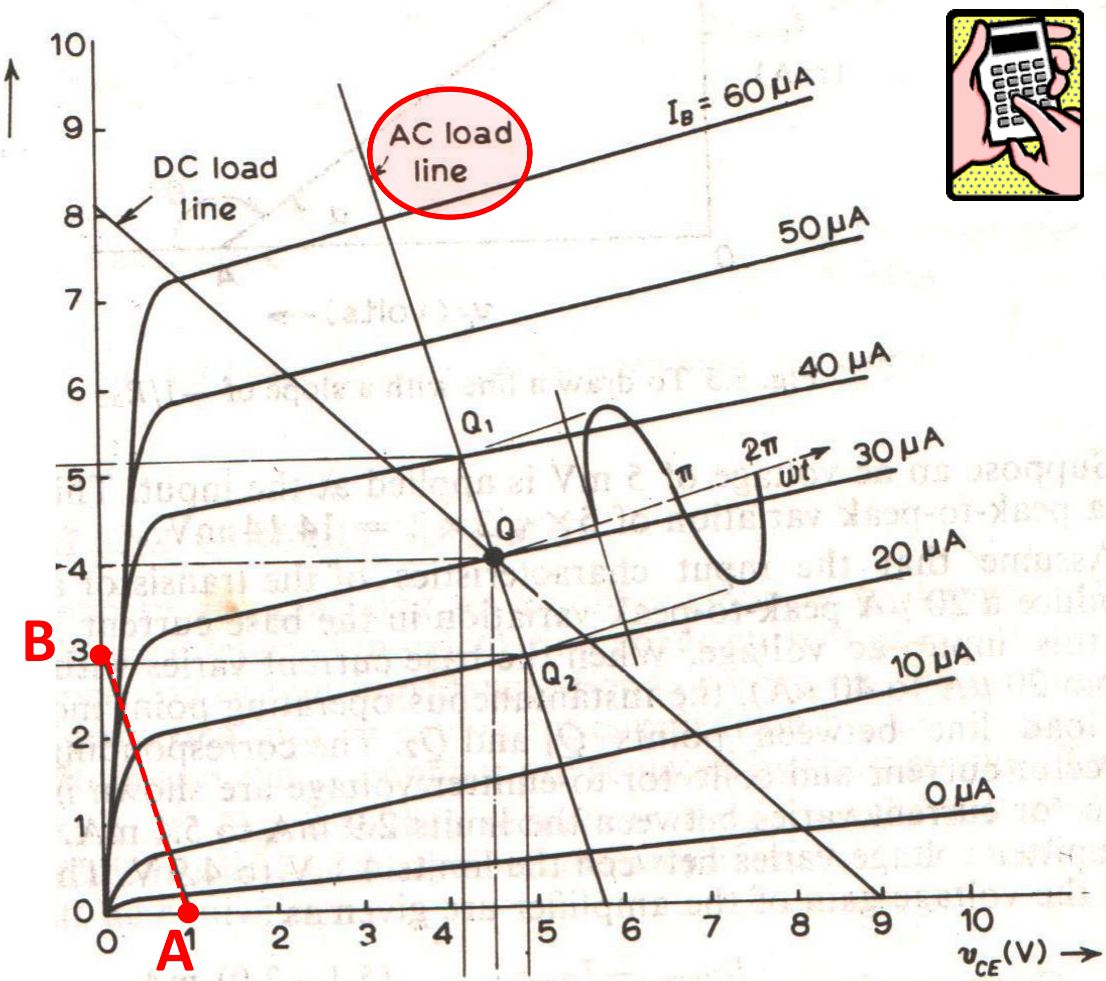
Graphical Method: AC Analysis

Determine the AC load line of the circuit.



Graphical Method: AC load line; Example





With AC signal

R_{ac} = Rc ‖ Ro= 320 Ω

and so 1/Rac = 0.0031

Slope of ac load line = 1/Rac

Draw line AB with

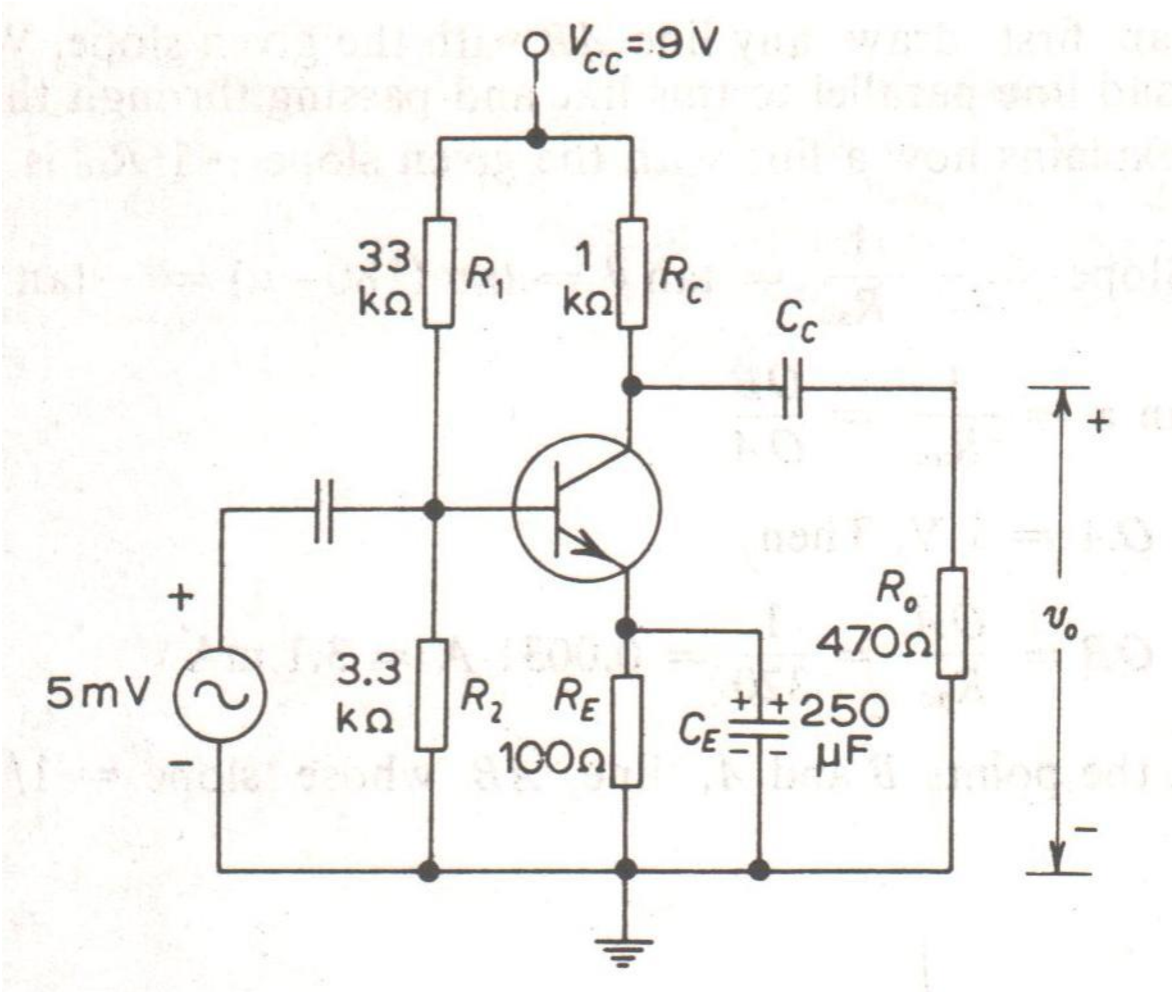
slope =OB/OA =1/Rac

If we set OA= 1V then slope = 1/R_{ac} = OB/1V .

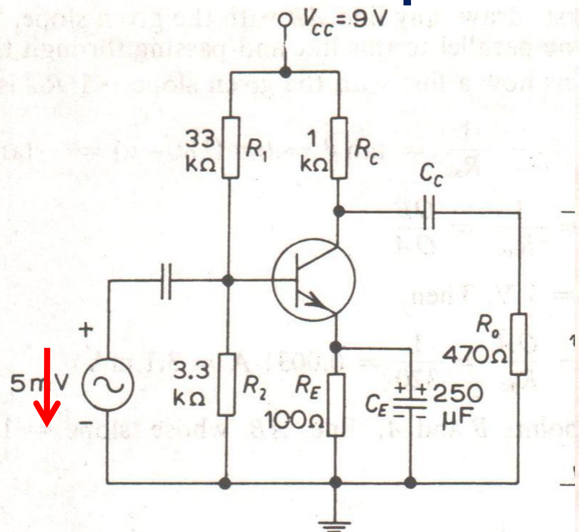
So we get OB = (1V/R_{ac}) Ampere = 3.1 mA

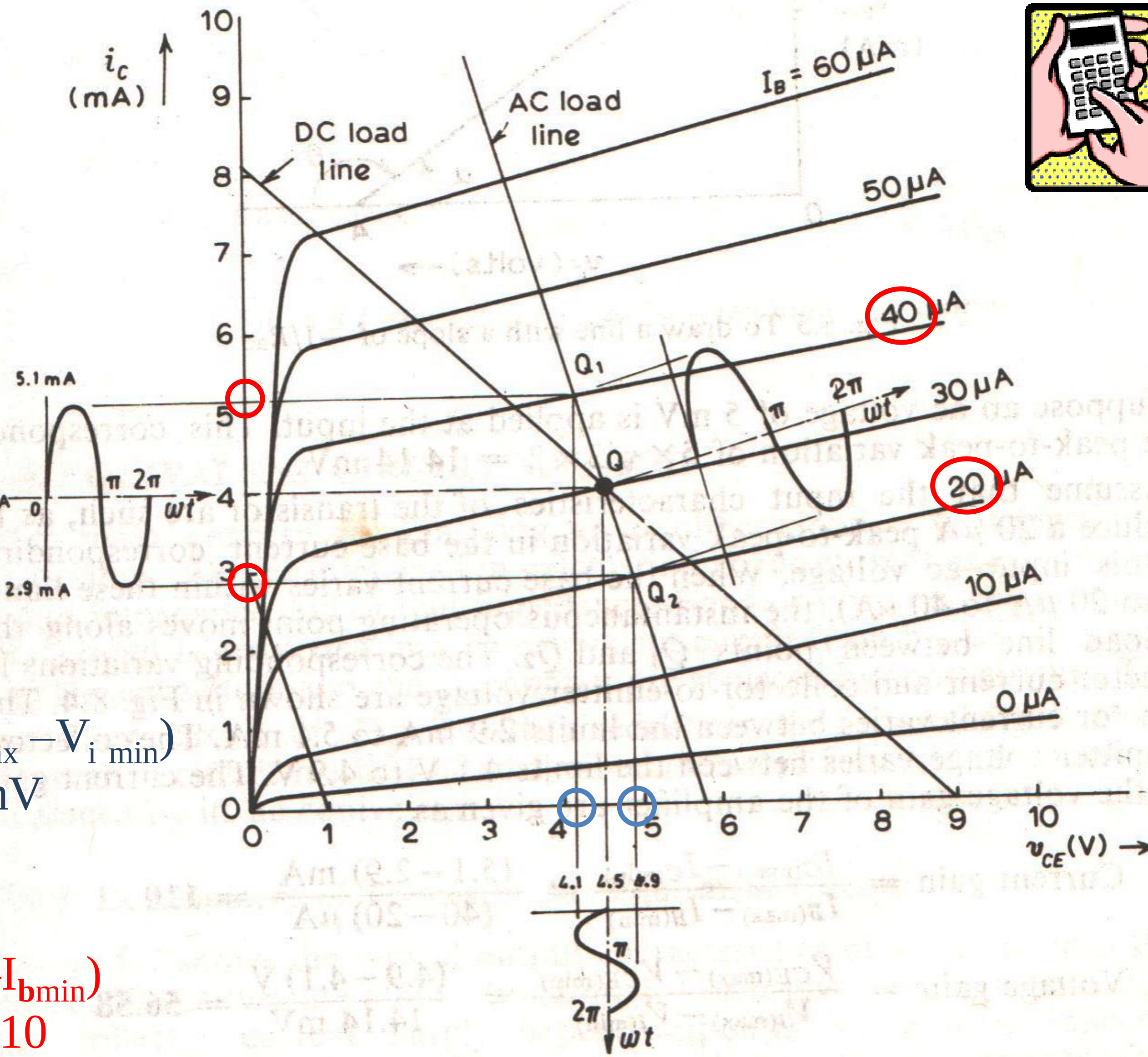
Hence we get co-rdinates of point B

Graphical Method: Calculation of Gain



Graphical Method: Calculation of Gain





With AC signal of 5 mV, peak to peak variation are 5x 2 x √2 =14.14mV

Voltage Gain

$A_v = (V_{CE\ max} - V_{Cmin}) / (V_{i\ max} - V_{i\ min})$

$= (4.9 - 4.1)$ V/ (14.14) mV

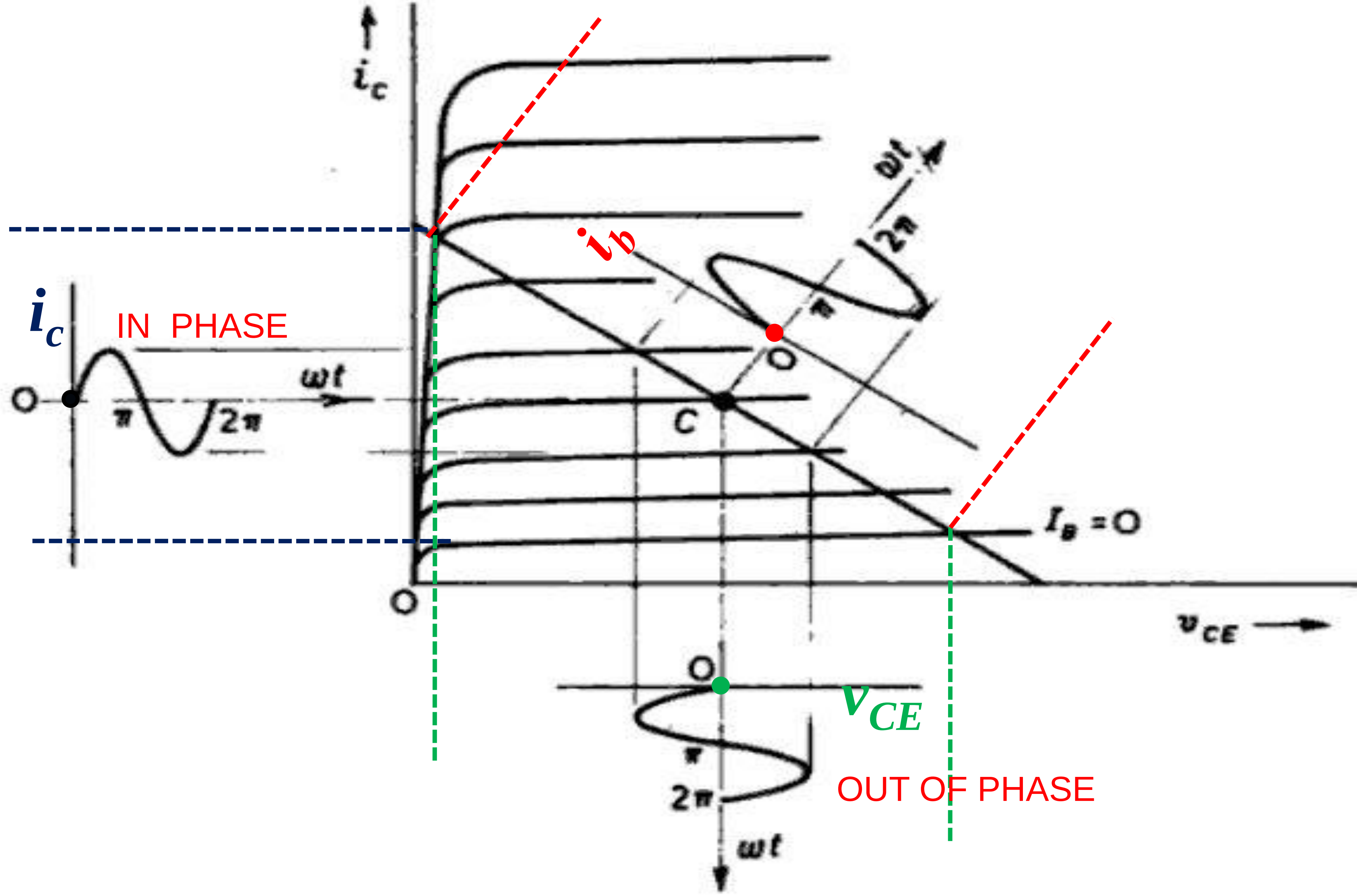
$= 56.58$

Current Gain

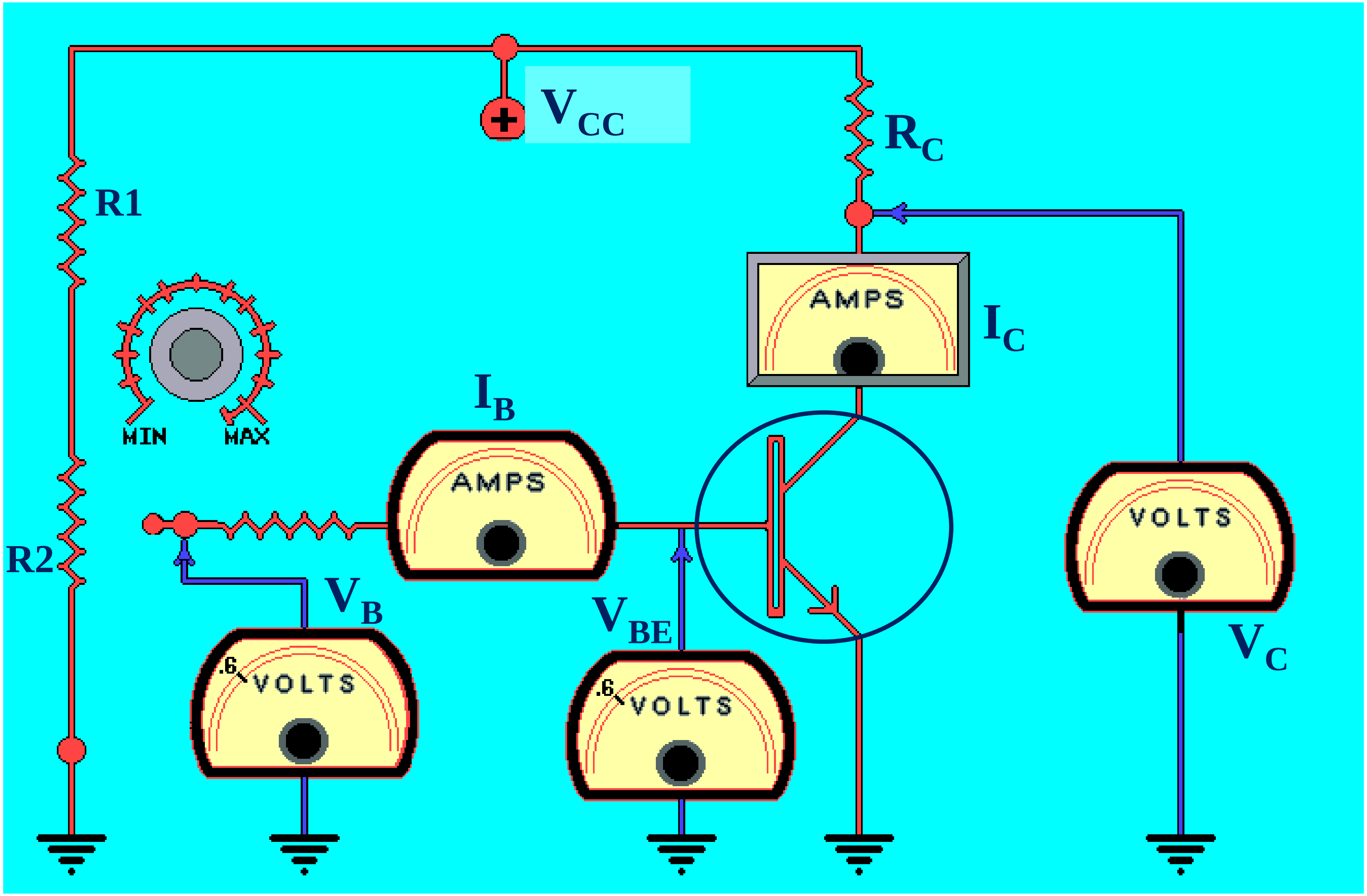
$= (I_{C\ max} - I_{Cmin}) / (I_{B\ max} - I_{bmin})$

$= (5.1 - 2.9) / (40 - 20) = 110$

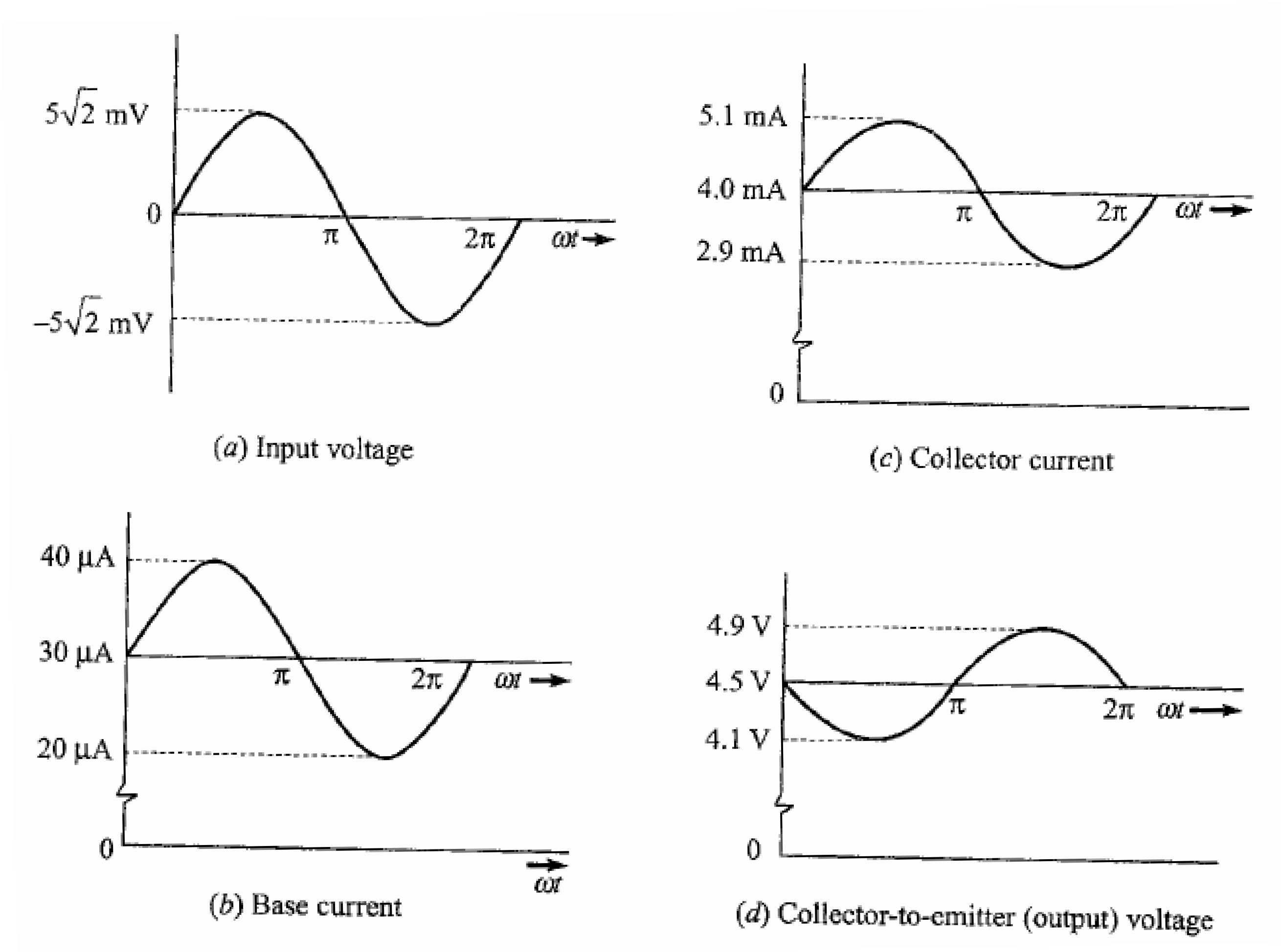
Graphical Method: input-output phase relations



Graphical Method: input output phase relations



Graphical Method: input output phase relations



Reference Book:

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D C Kulshreshtha

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