Huazhong University of Science and Technology
The Department of Electronics and Information Engineering



First Term 09/10

Electronic Circuit Analysis and Design

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Email:

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5.2 DC Analysis of Transistor Circuits

1. DC Analysis of Common-Emitter Circuit

2. Basic Transistor Application

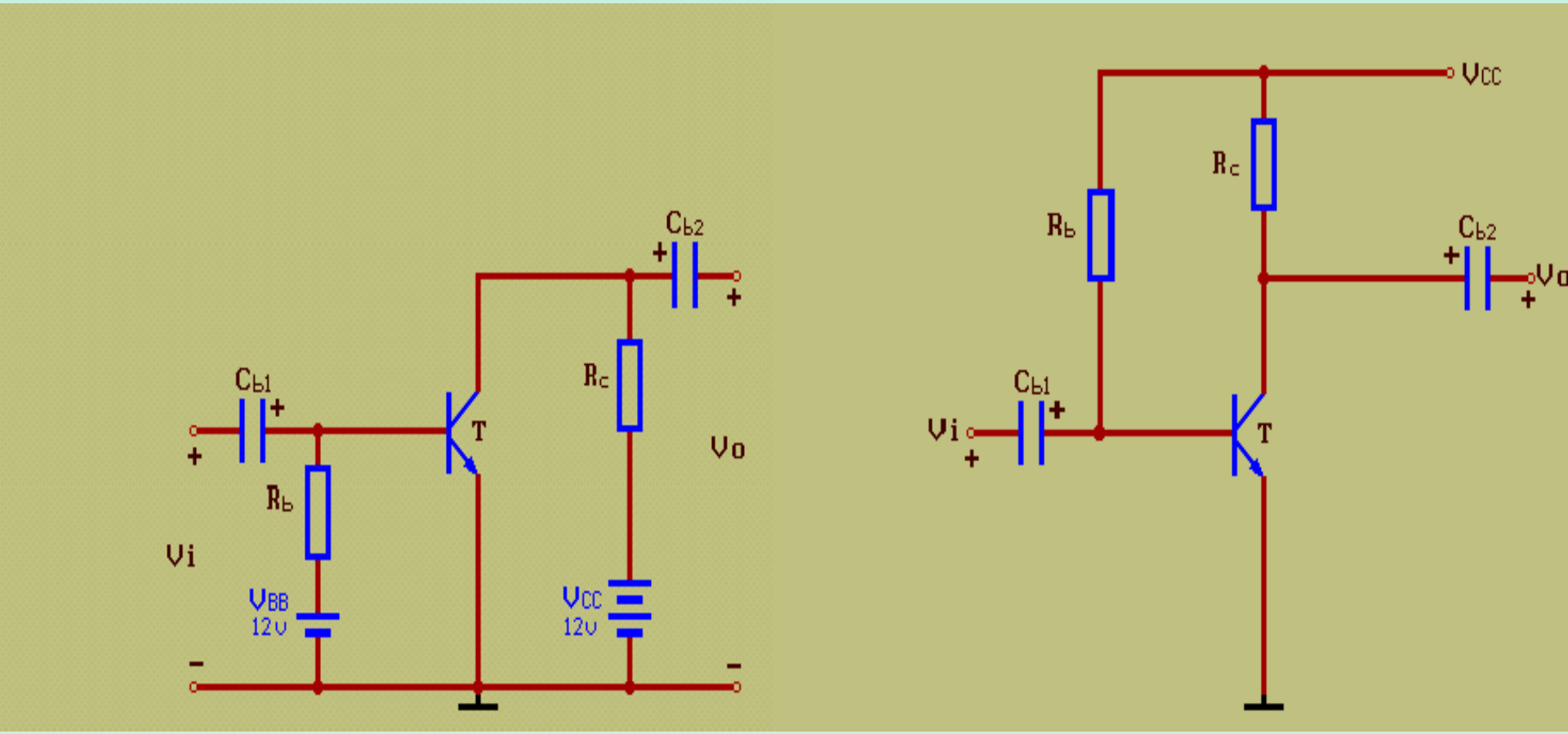
5.2.3 Bipolar Transistor Biasing

5.2 DC Analysis of Transistor Circuits

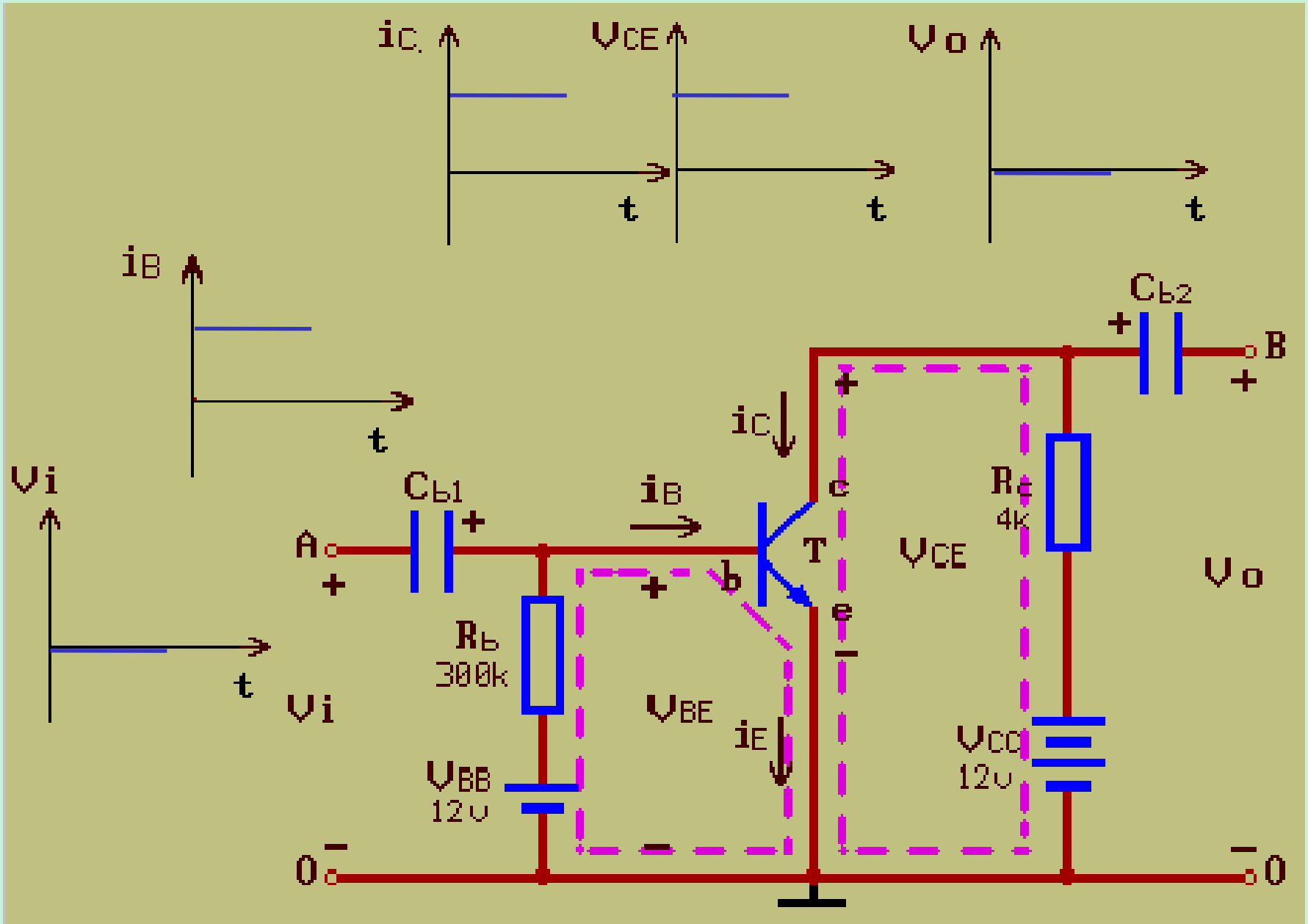
What are DC and AC Analyses?

- Dc analysis: Because of the applied dc voltage source, transistor must be biased in the forward-active region so that it can be act as amplifying device.
- Ac analysis: because of the time-varying signal source, we want the output signal to be linearly amplifying to the input signal.
- Quiescent point (Q-point): If a transistor is biased with dc voltages, The biasing point can be determined. Generally we use $\boldsymbol{I_B}$, $\boldsymbol{I_C}$ and V_{CE} （or I_{BQ}, I_{CQ},and V_{CEQ} ） to represent Q-point.

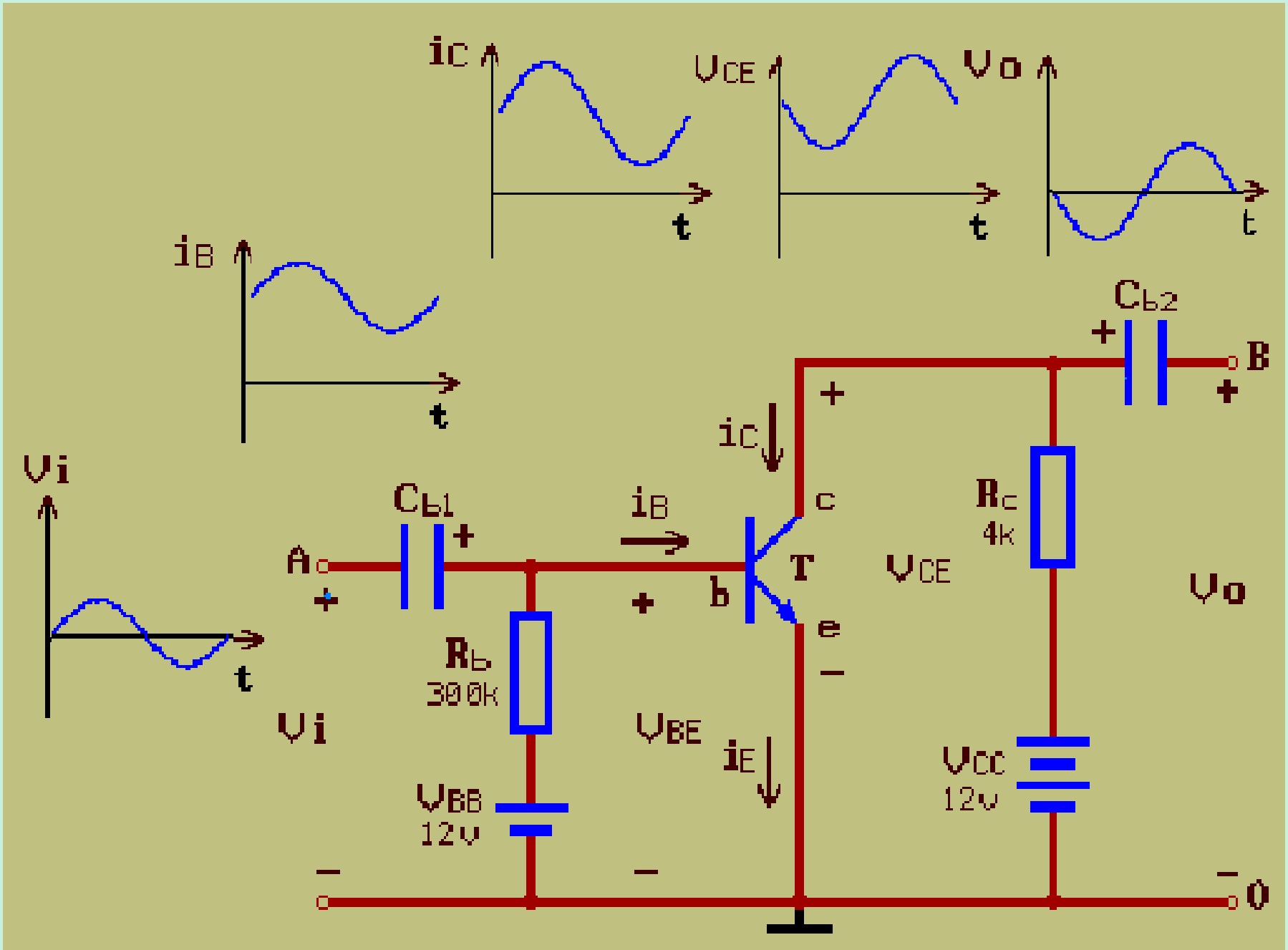
Transistor Circuits



$v_i=0$


iC
VCE
Vo
t
t
t
iB
t
Cb2
B
+
Vi
Cb1
iB
iC
c
Rc
4k
A
+
T
VCE
Vo
b
+
e
Rb
300k
VBE
iE
Vi
t
VBB
12v
VCC
12v
0
0

$v_i = V \sin \omega t$



5.2 DC Analysis of Transistor Circuits

What are DC and AC Analyses?

There are two kinds of quantities in the circuit. One is a dc quantity, other is a ac signal, so we use the different notation to represent them. E.g.

I_B , V_{BE} DC values

i_b , v_{be} Instantaneous ac values

i_B , v_{BE} Total instantaneous values

$$i_B = I_B + i_b, \quad v_{BE} = V_{BE} + v_{be}$$

I_b , V_{be} phasor values

 # Why an amplifier must be established a appropriate dc biasing?

5.2.1 DC Analysis of CE

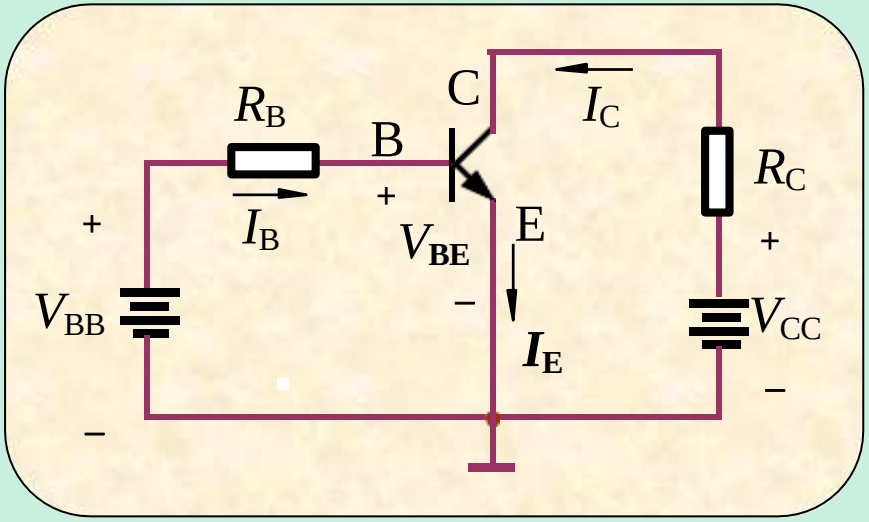
1. Determining Q-Point Using Approximation Equations

- If we use this method, we must know current gain β.

$$I_B = \frac{V_{BB} - V_{BE}}{R_B}$$

$$I_C = \beta I_B$$

$$V_{CE} = V_{CC} - I_C R_C$$



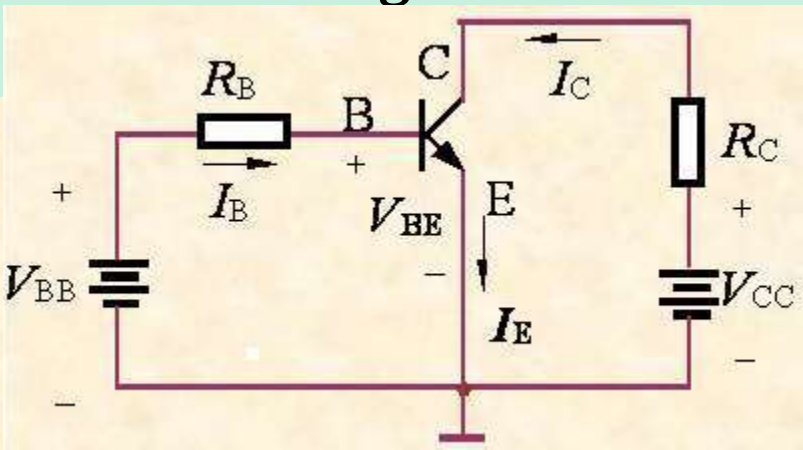
Common-emitter circuit

Generally V_{BE}=0.7V for silicon, and V_{BE}=0.2V for germanium.

5.2.1 DC Analysis of CE

2. Determining Q-Point Using Graphical Technique

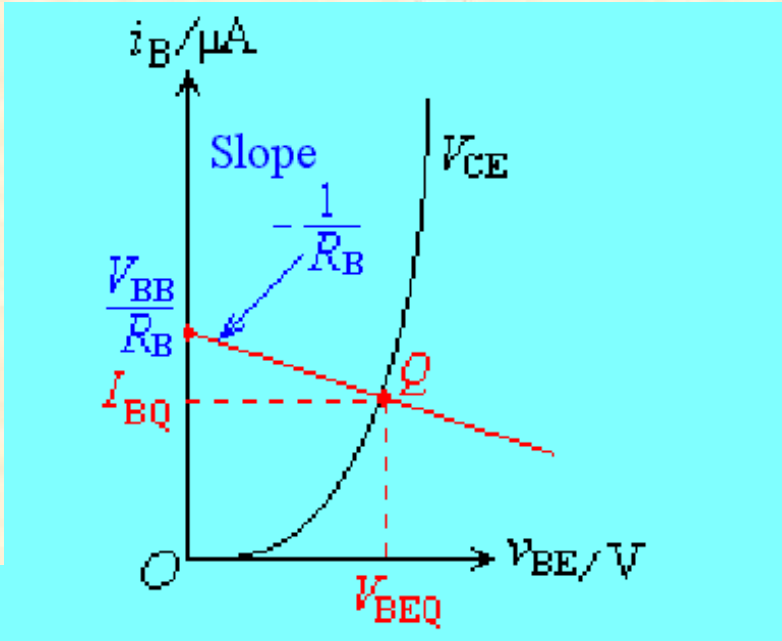
- **If we use this approach, we must know current-voltage characteristics.**



- **Input load line is obtained around B-E loop.**

$$V_{BE} = V_{BB} - I_B R_B$$

- **This equation produces a straight-line relationship on input characteristic curve, the intersection provides Q-point. We get I_{BQ}.**



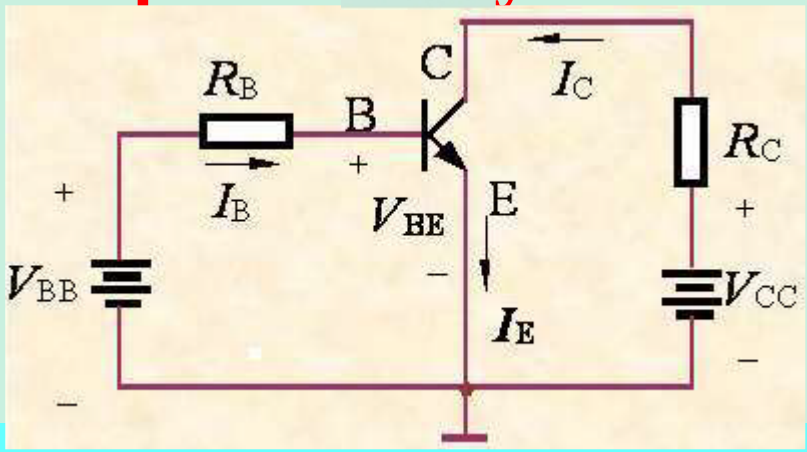
5.2.1 DC Analysis of CE

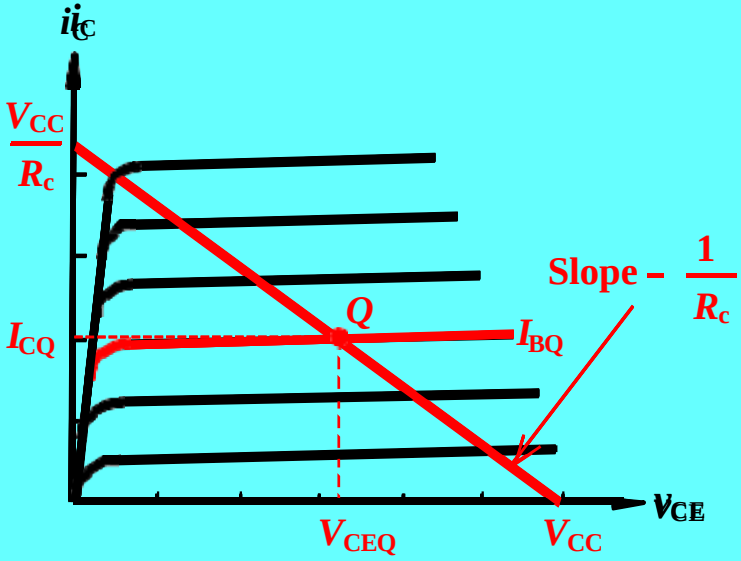
2. Determining Q-Point Using Graphical Analysis

- **Output load line is obtained around C-E loop.**

$$V_{CE}=V_{CC}-I_CR_c$$

- **This equation produces a straight-line relationship on output characteristic curve, the intersection provides Q-point. We get V_{CEQ} and I_{CQ}**





5.2.2 Basic Transistor Application

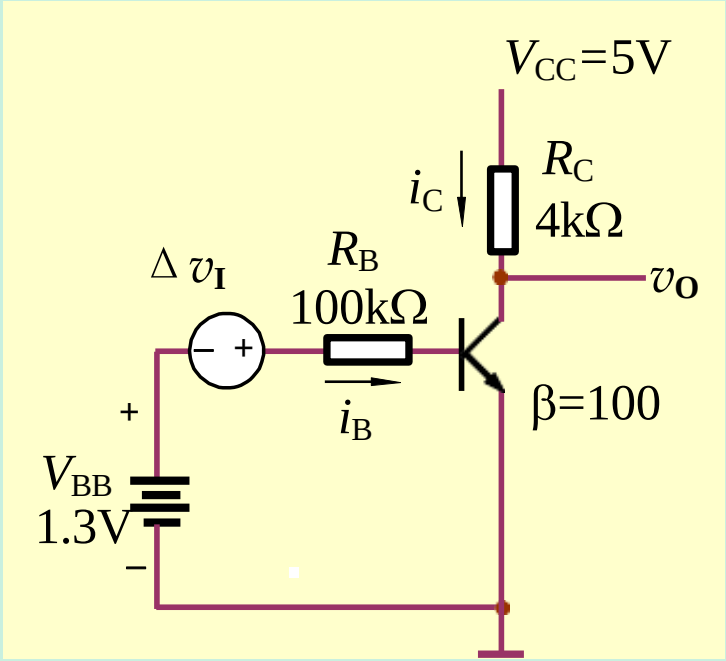
1. Amplifier

- Assume transistor operates in forward-active mode.

$$i_B = \frac{V_{BB} + \Delta v_I - V_{BE}}{R_B} = \frac{0.6 + \Delta v_I}{R_B}$$

$$\boldsymbol{v_O = V_{CC} - i_C R_C = V_{CC} - \beta i_B R_C}$$

$$\boldsymbol{= 2.6 - 4(\Delta v_I)}$$



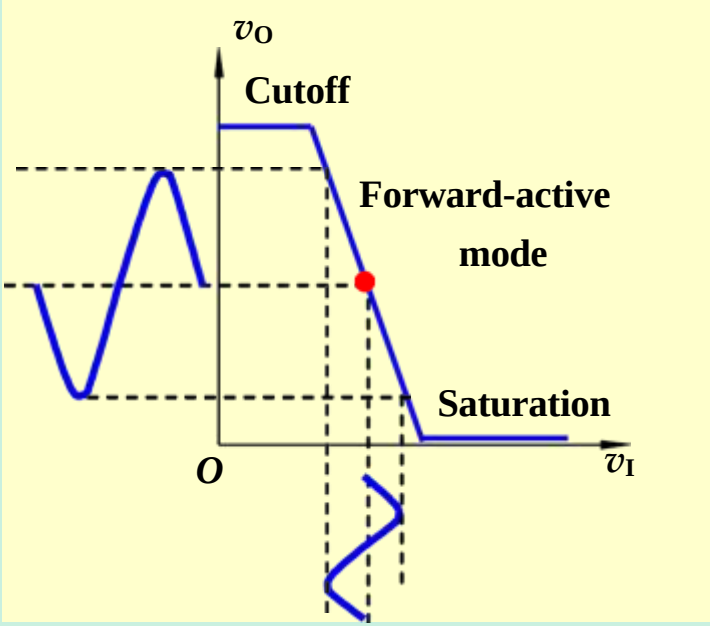
AC component $\Delta v_O = -4(\Delta v_I)$

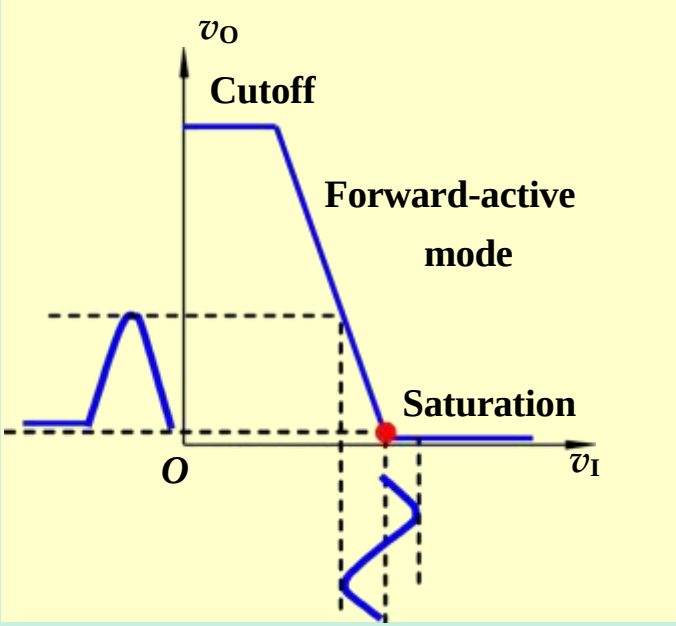
Voltage gain $A_v = \dfrac{\Delta v_O}{\Delta v_I} = -4$

5.2.2 Basic Transistor Application

1. Amplifier

- If transistor operates in forward-active mode, output waveform is sinusoidal..
- If Q-point is too high or low, output waveform is distorted.



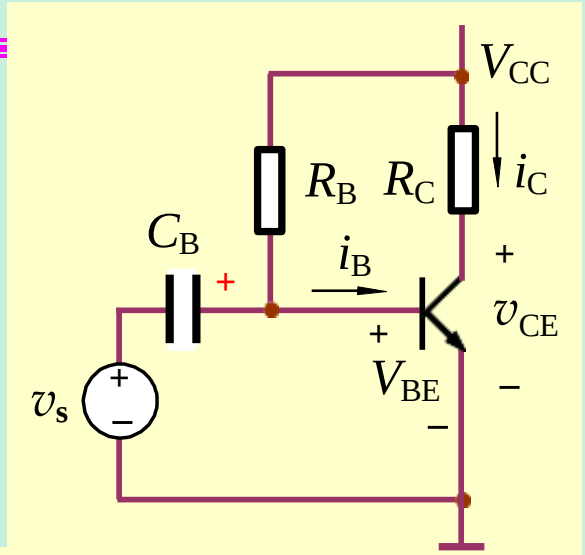


5.2.3 Bipolar Transistor Biasing

1. Single base resistor biasing

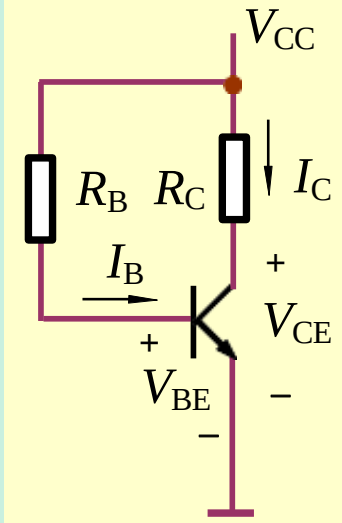
- There are the coupling capacitors in some circuits, shown in fig.

2. DC and AC Equivalent Circuits

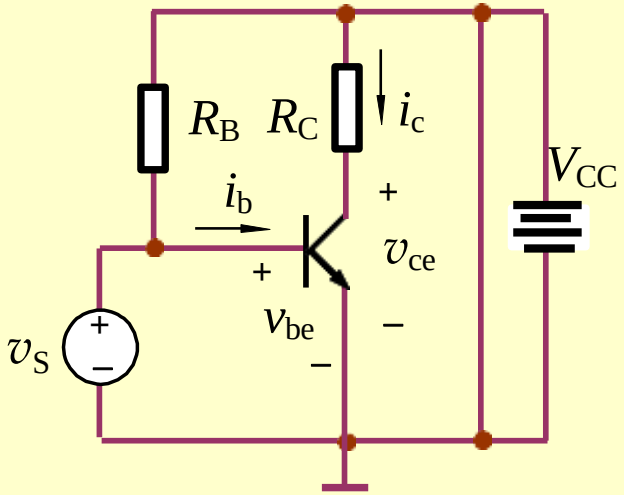


•Coupling capacitor: Acting as a short circuit in ac analysis, and as an open circuit in dc analysis

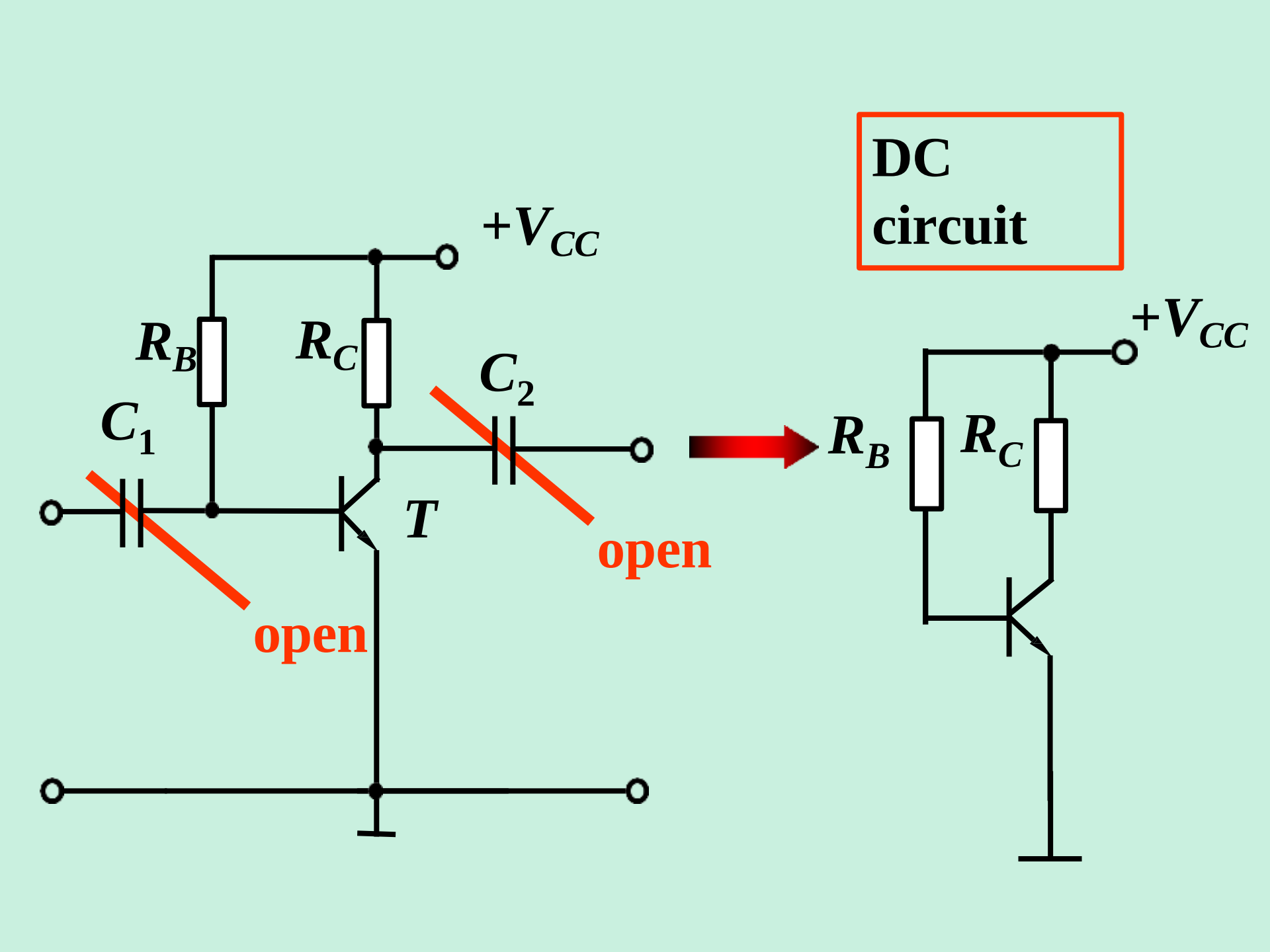
•dc voltage sources : The resistance in ac analysis is zero， acting as a short circuit in ac analysis.



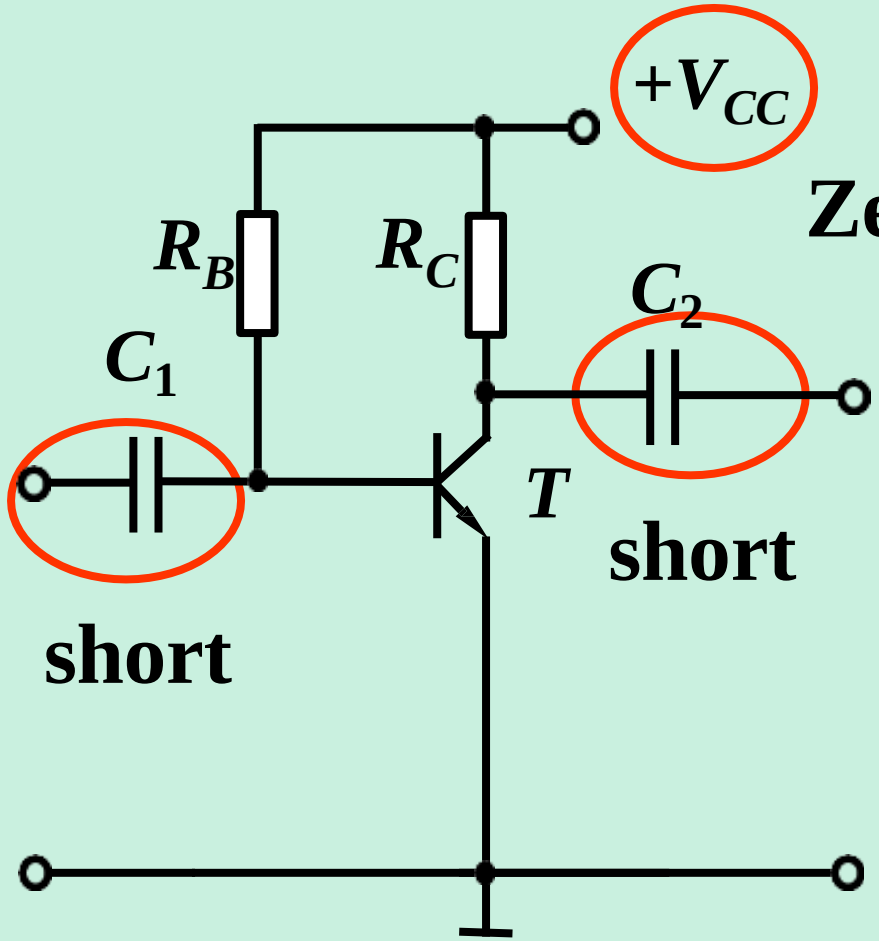
DC equivalent circuit



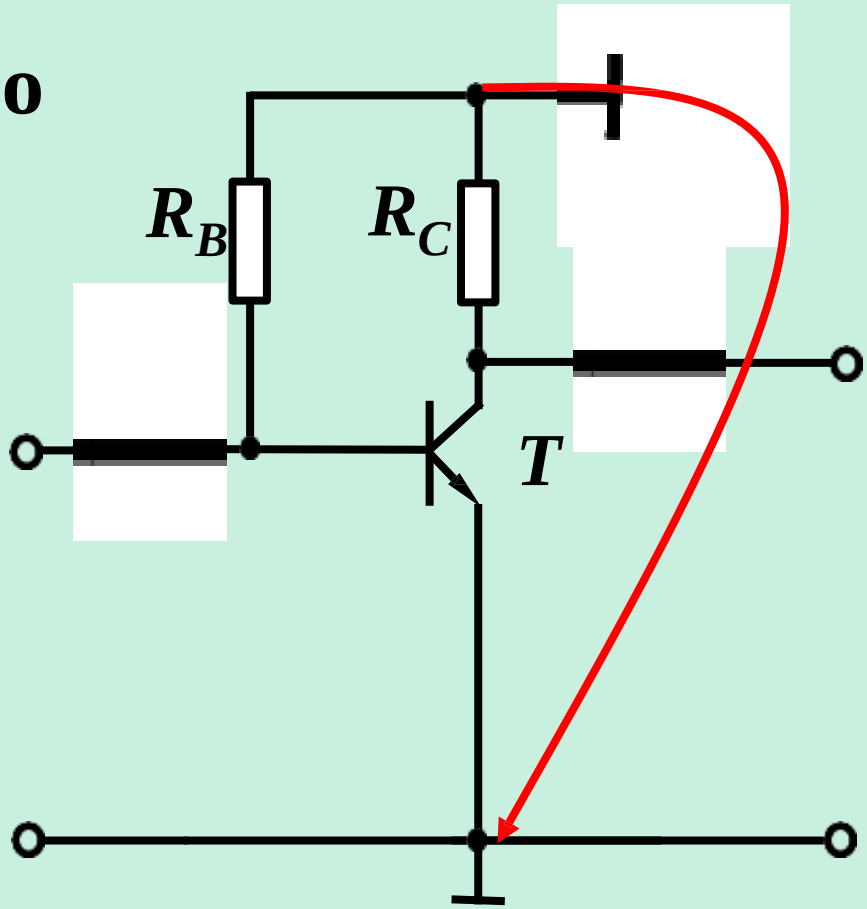
AC equivalent circuit

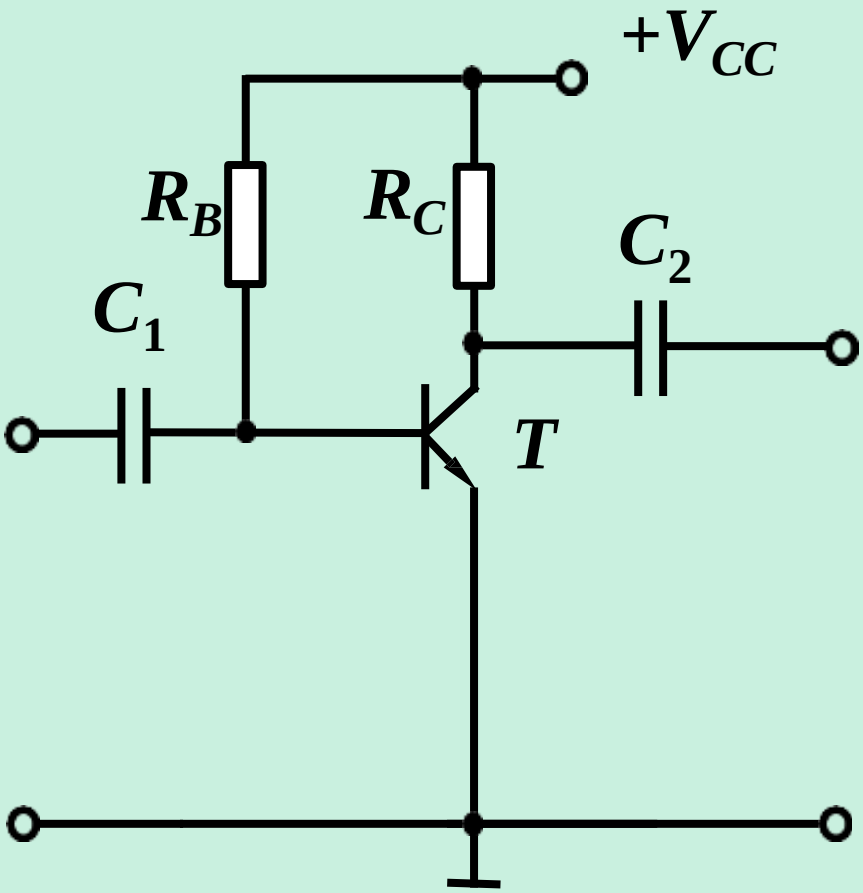

DC
circuit
+V_{CC}
R_B
R_C
C_1
C_2
T
open
open
+V_{CC}
R_B
R_C

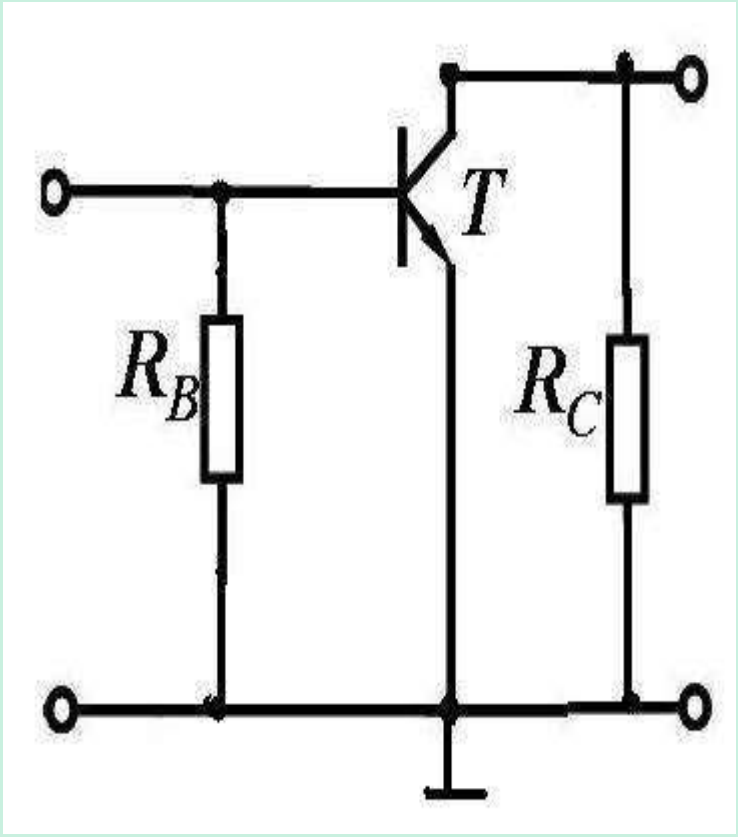
AC circuit



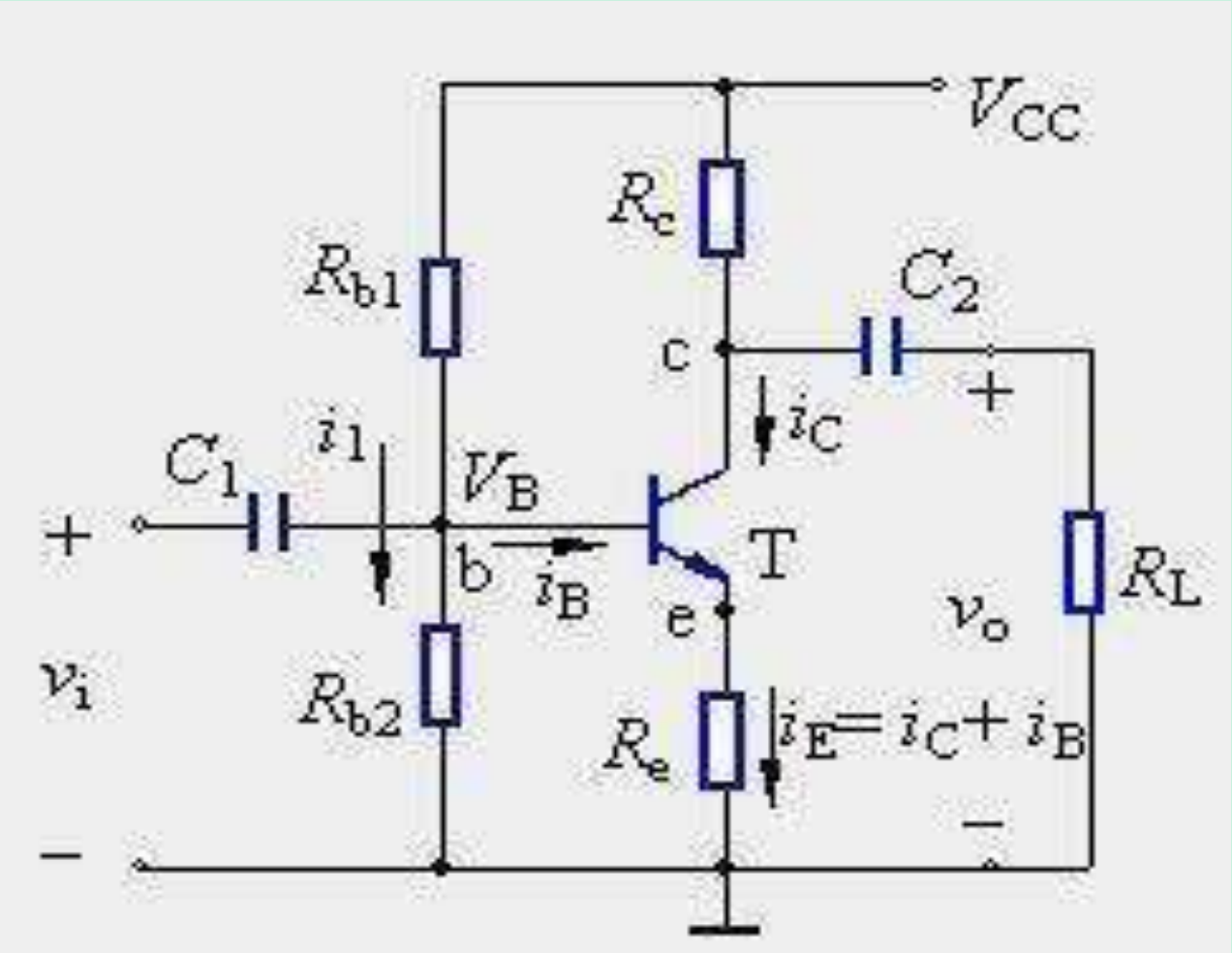
Zero

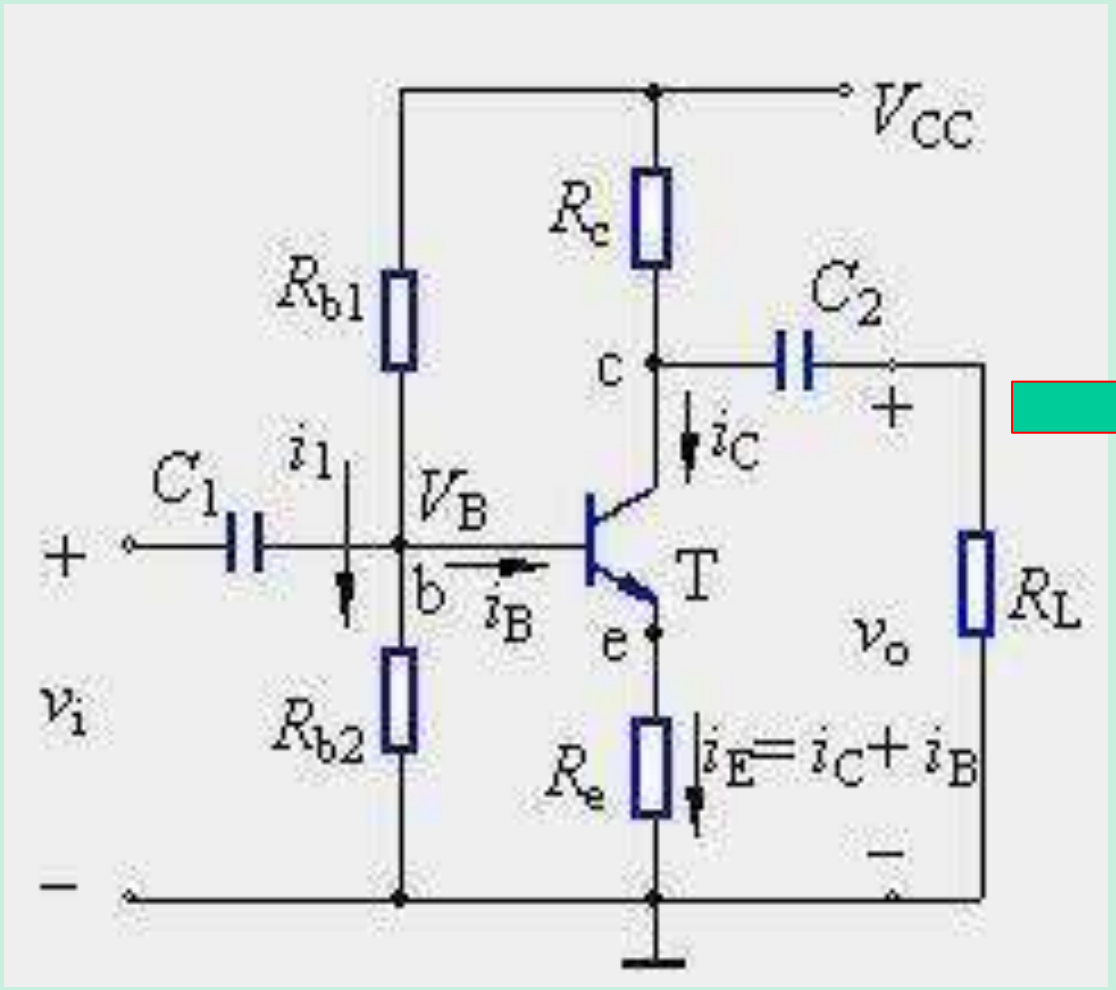


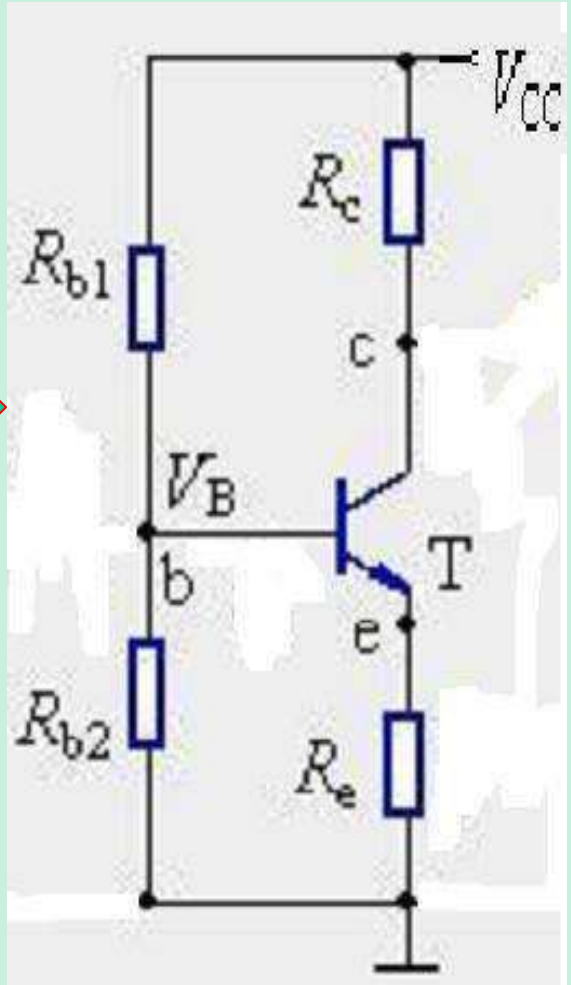

+V_{CC}
R_B
R_C
C_2
C_1
T

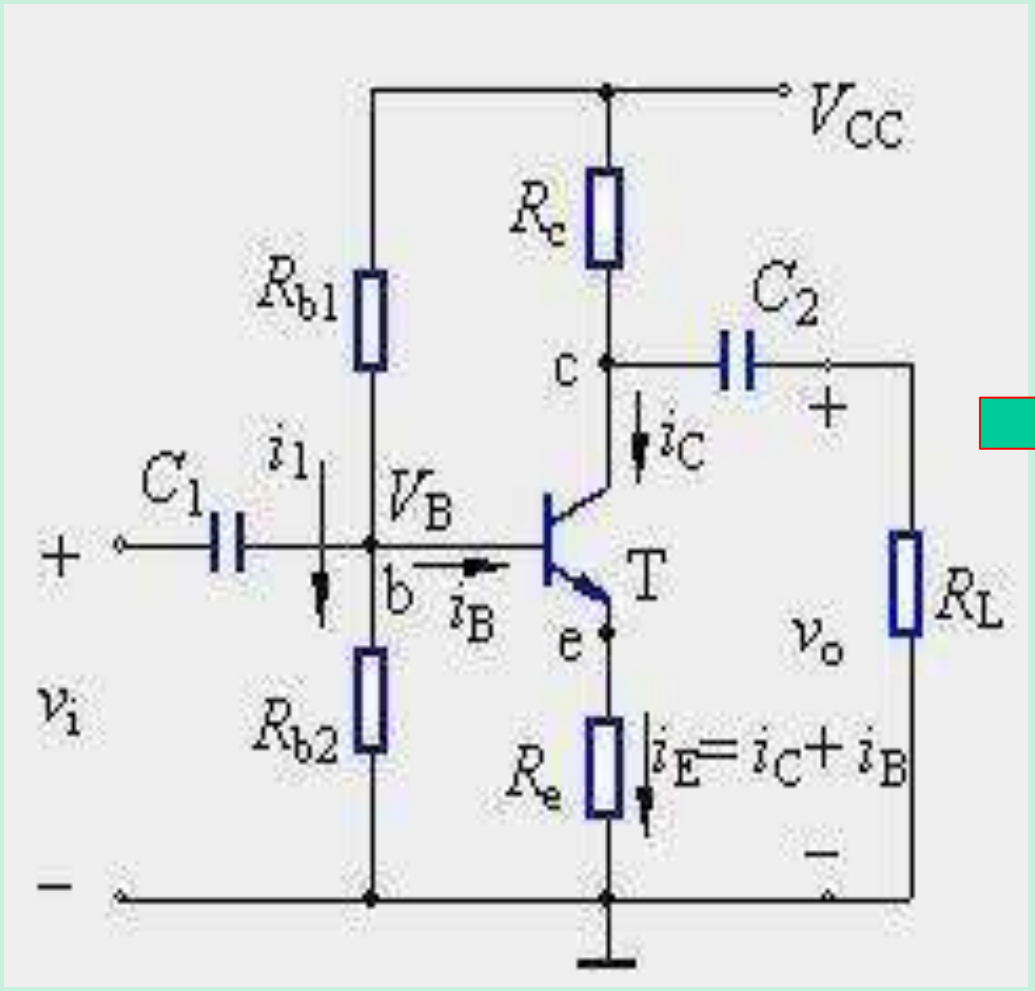

T
R_B
R_C

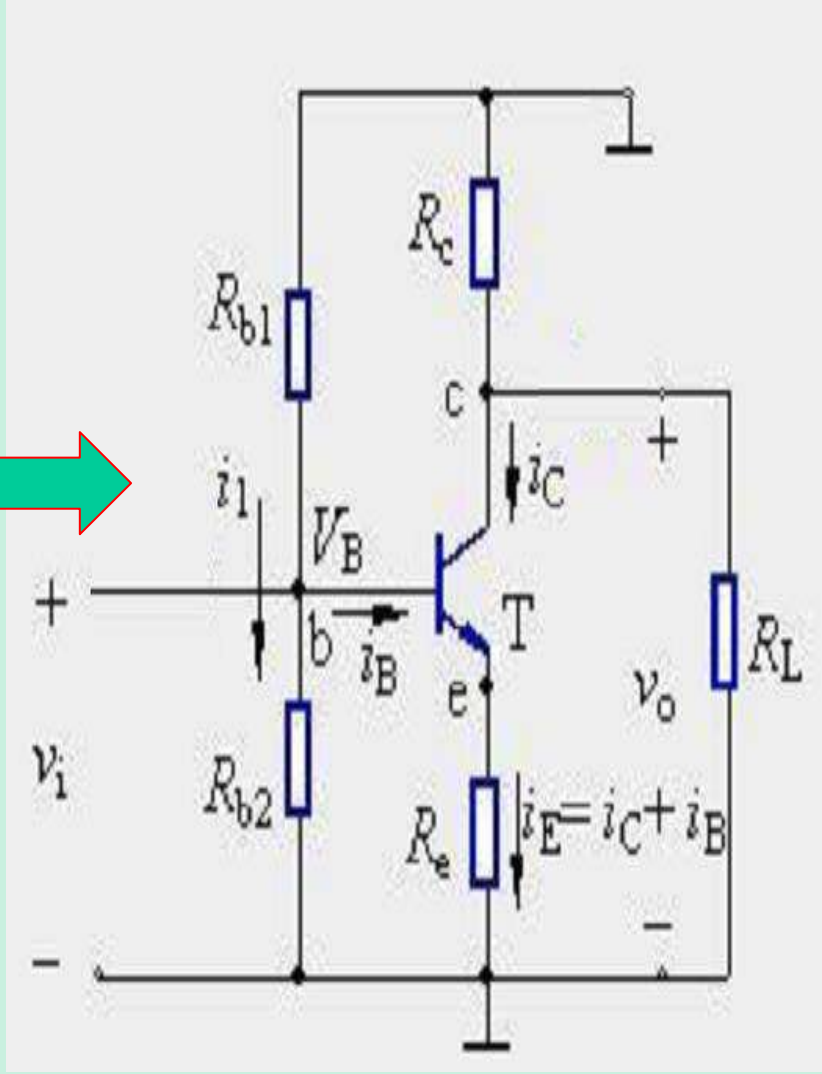
Sketch the DC circuit and AC Equivalent circuit

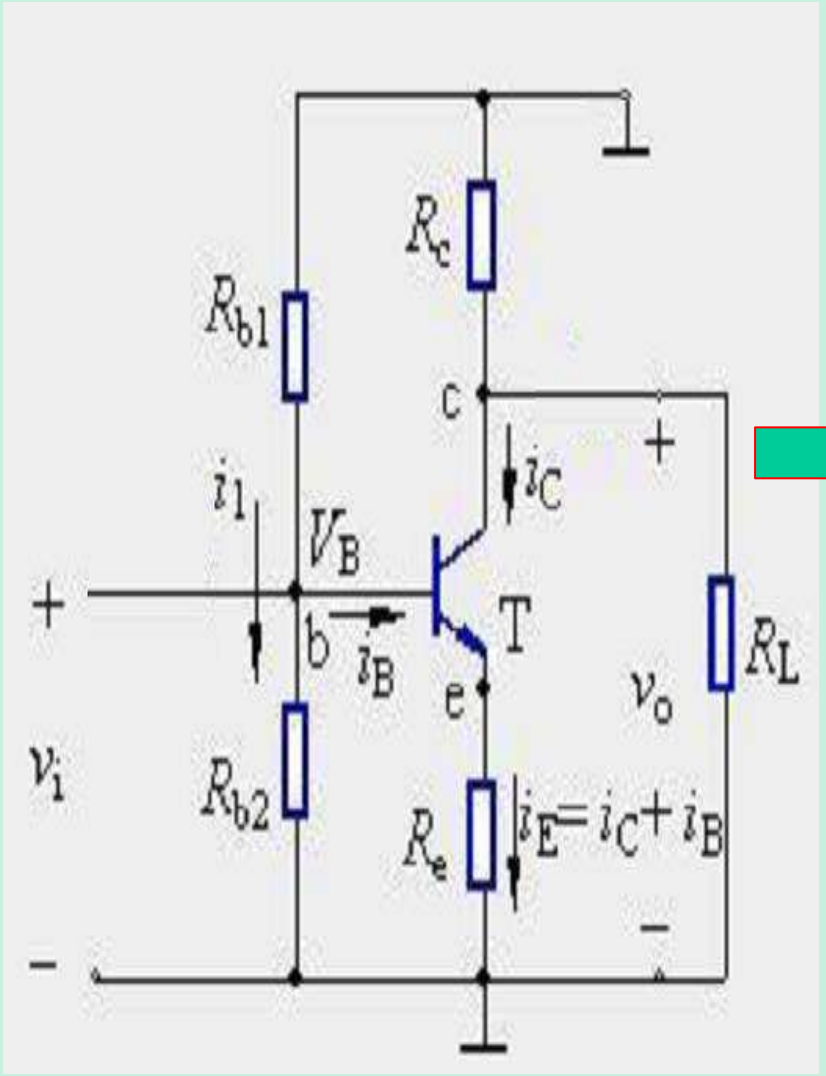


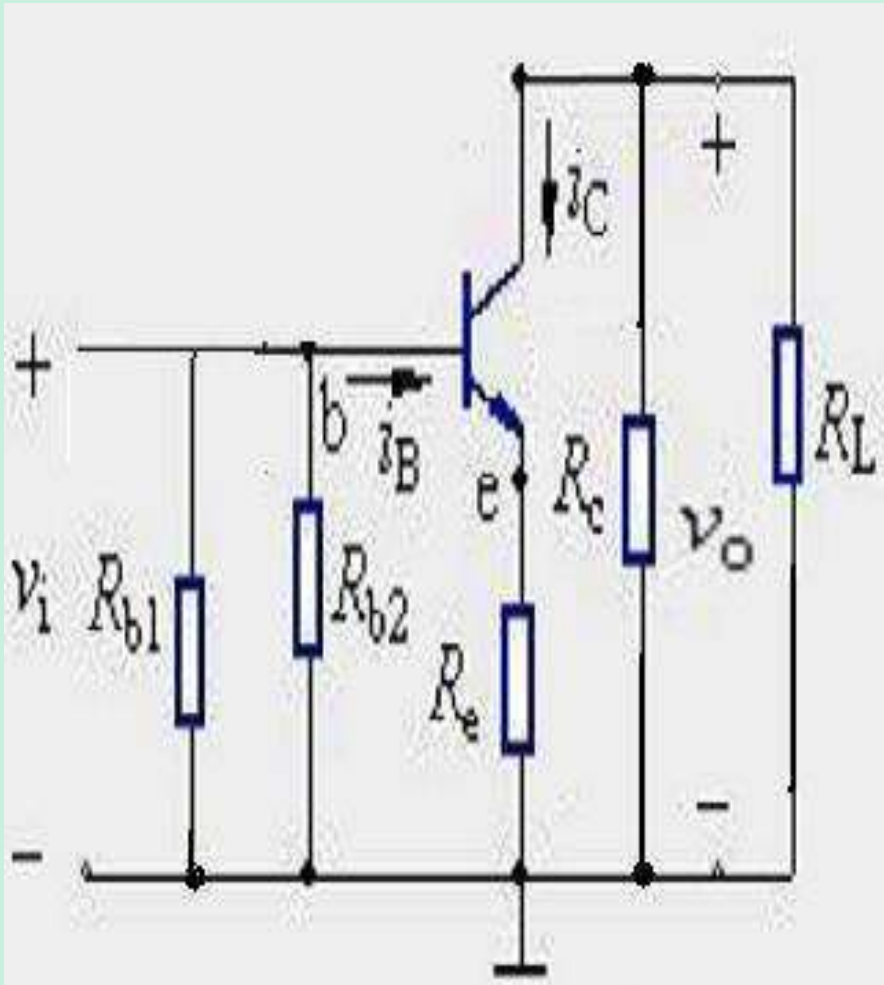

V_{CC}
R_c
R_{b1}
C_2
c
i_C
+
C_1
i_1
V_B
+
b
i_B
T
R_L
e
v_o
v_i
R_{b2}
R_e
$i_E = i_C + i_B$
−
−


V_{CC}
R_c
R_{b1}
c
V_B
T
b
e
R_{b2}
R_e

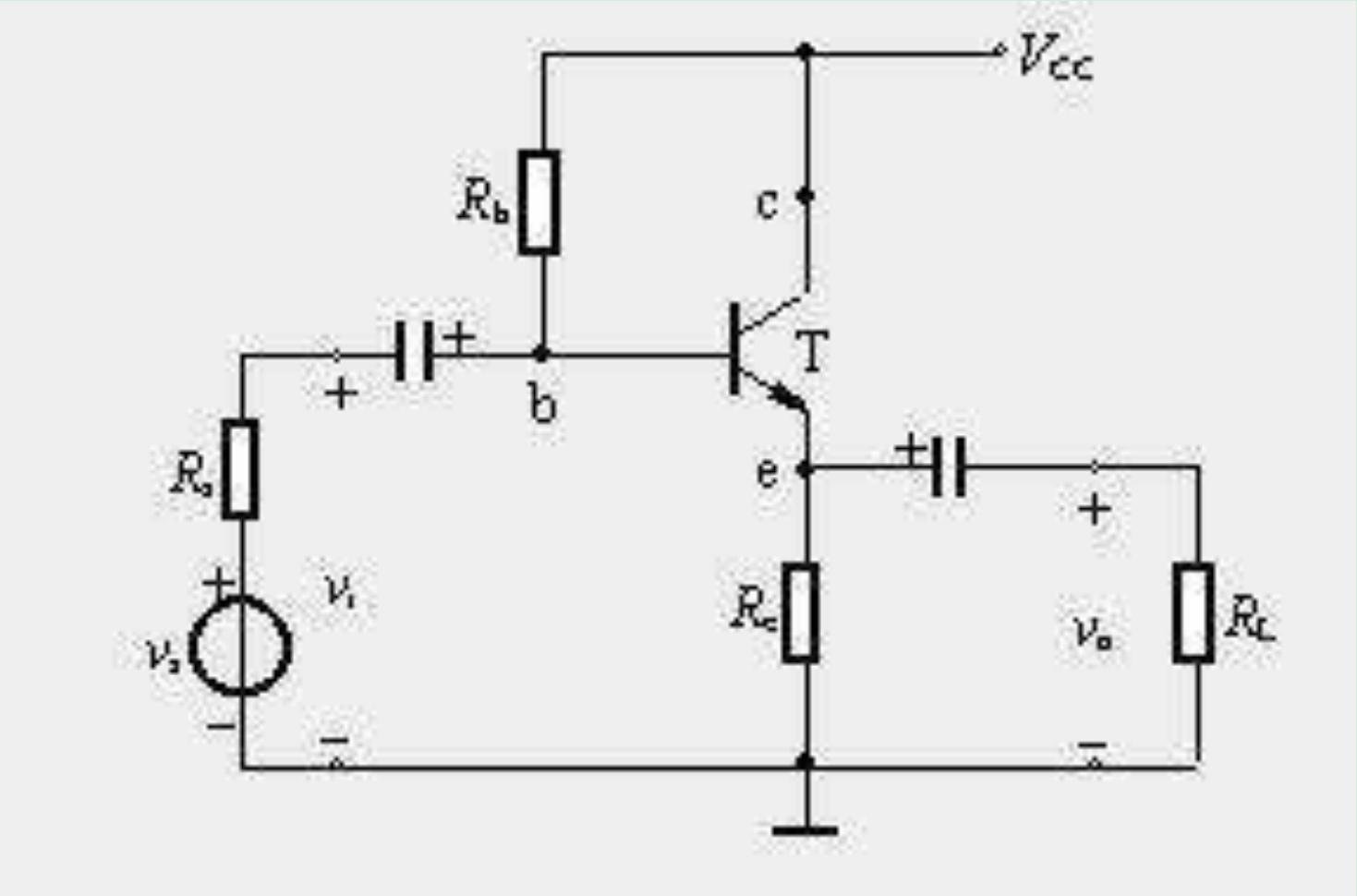

V_{CC}
R_c
R_{b1}
C_2
c
i_C
+
C_1
i_1
V_B
+
b
i_B
T
R_L
e
v_o
v_i
R_{b2}
R_e
$i_E = i_C + i_B$
−
−

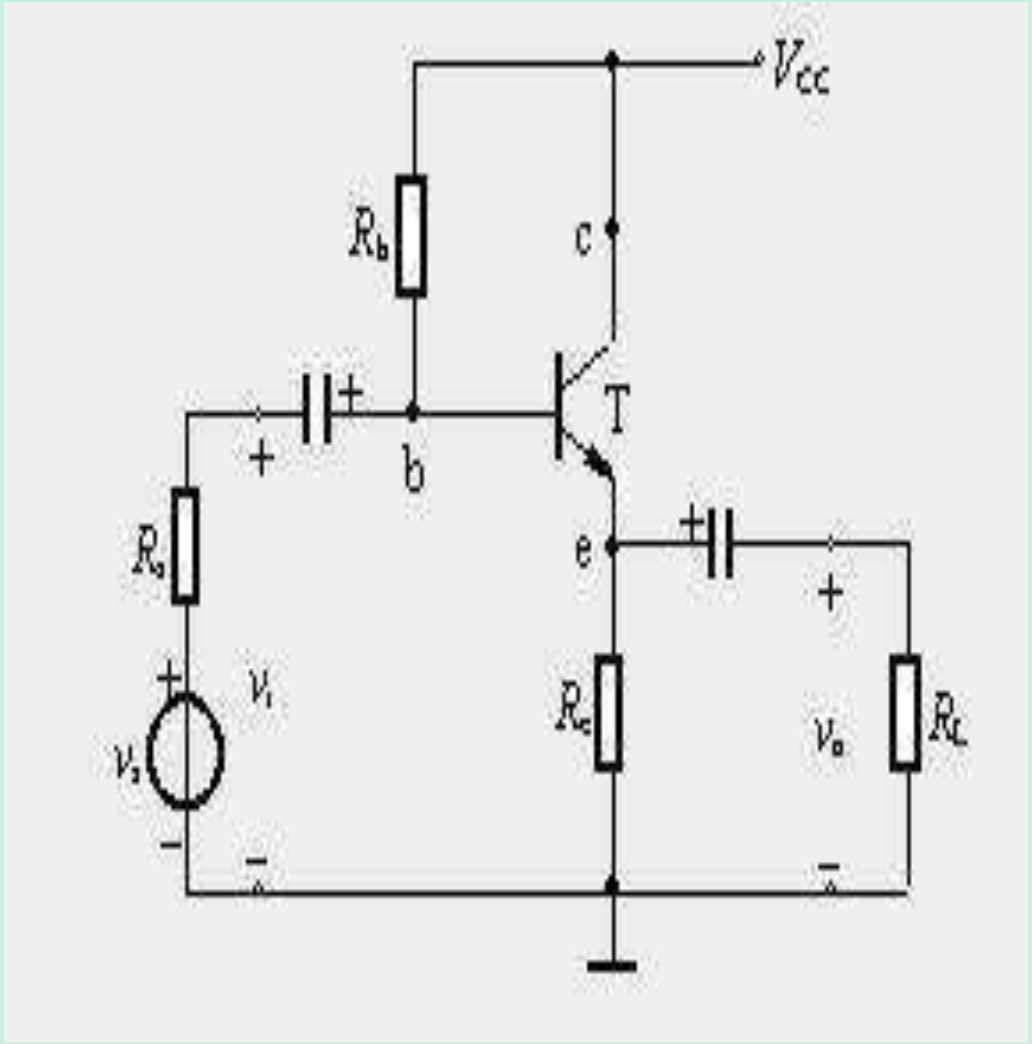

R_c
R_{b1}
c
+
i_1
i_C
V_B
+
b
i_B
T
R_L
e
v_o
v_i
R_{b2}
R_e
$i_E = i_C + i_B$
−
−

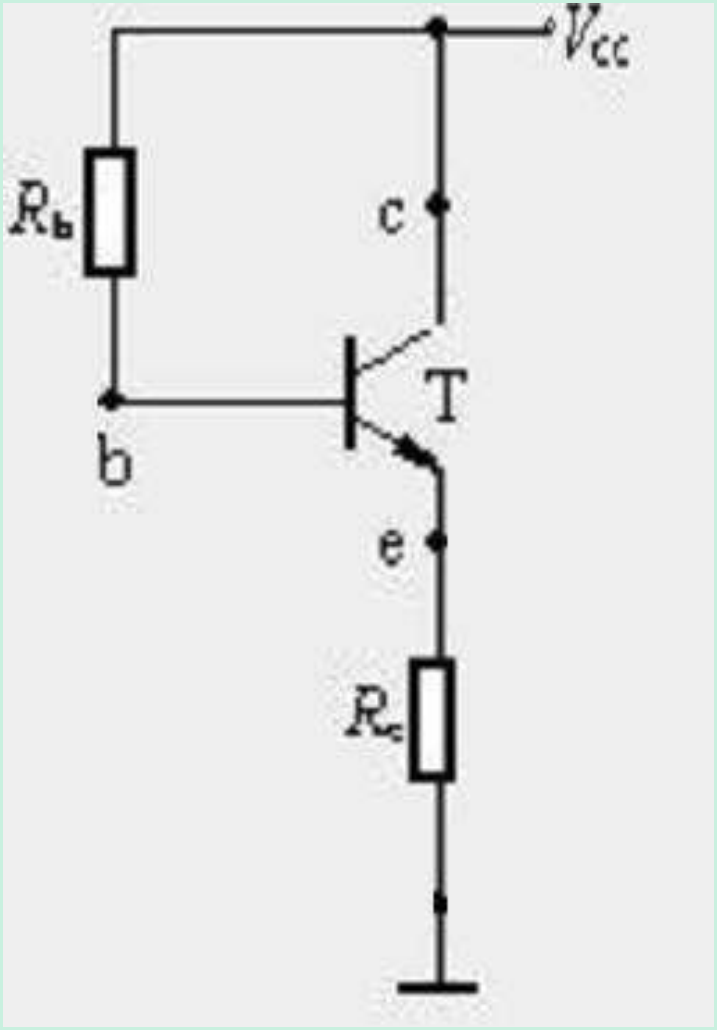

R_c
R_{b1}
c
i_C
+
i_1
V_B
+
T
b
i_B
e
v_o
R_L
v_i
R_{b2}
R_e
$i_E = i_C + i_B$
−
−

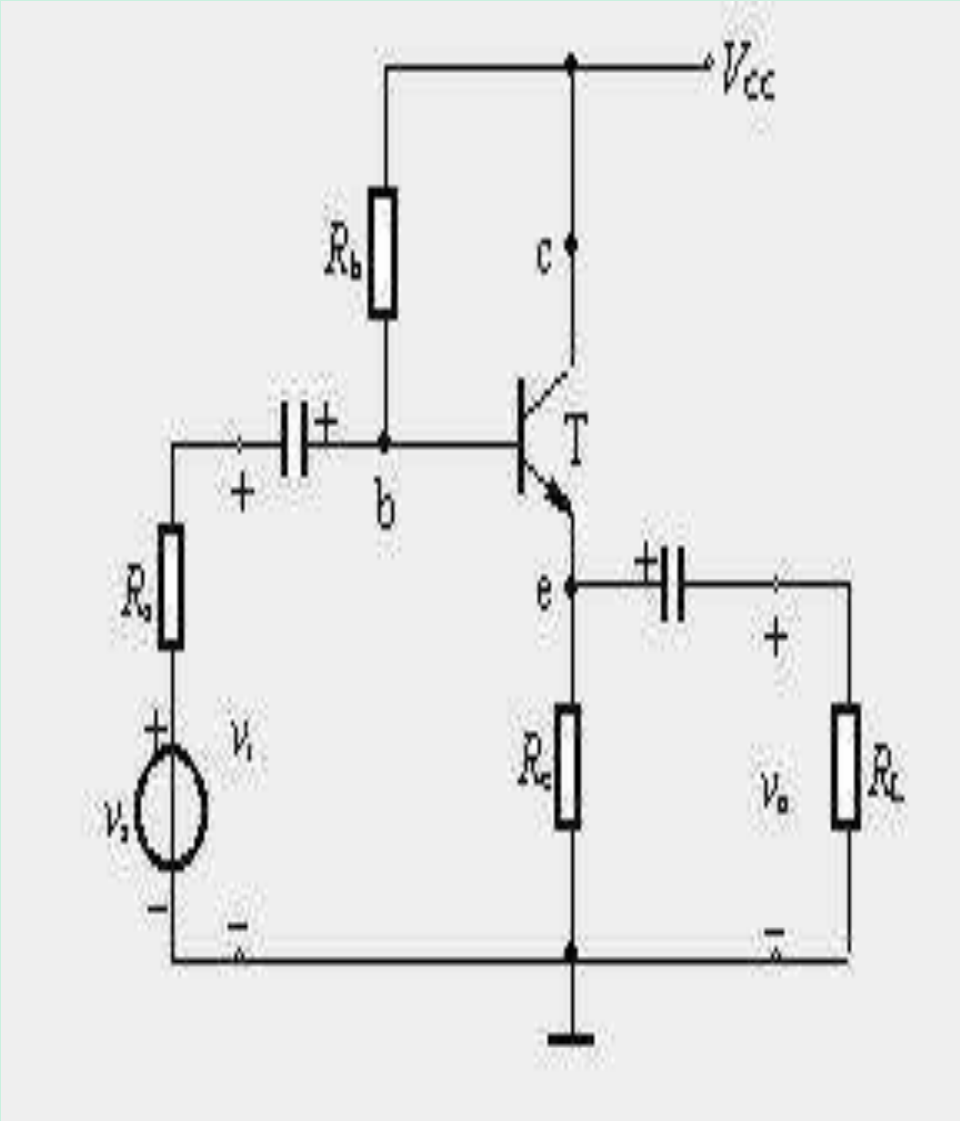

i_C
+
+
b
i_B
e
R_c
v_o
R_L
v_i
R_{b1}
R_{b2}
R_e
−
−

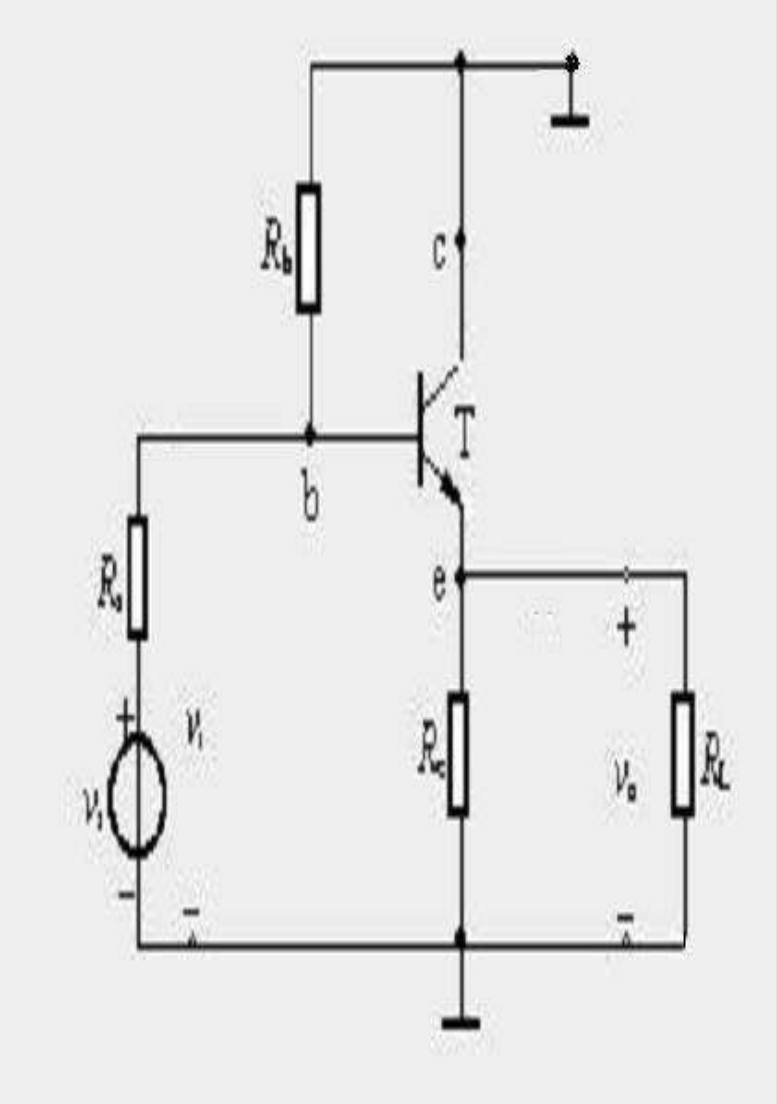
Sketch the DC circuit and AC Equivalent **circuit**

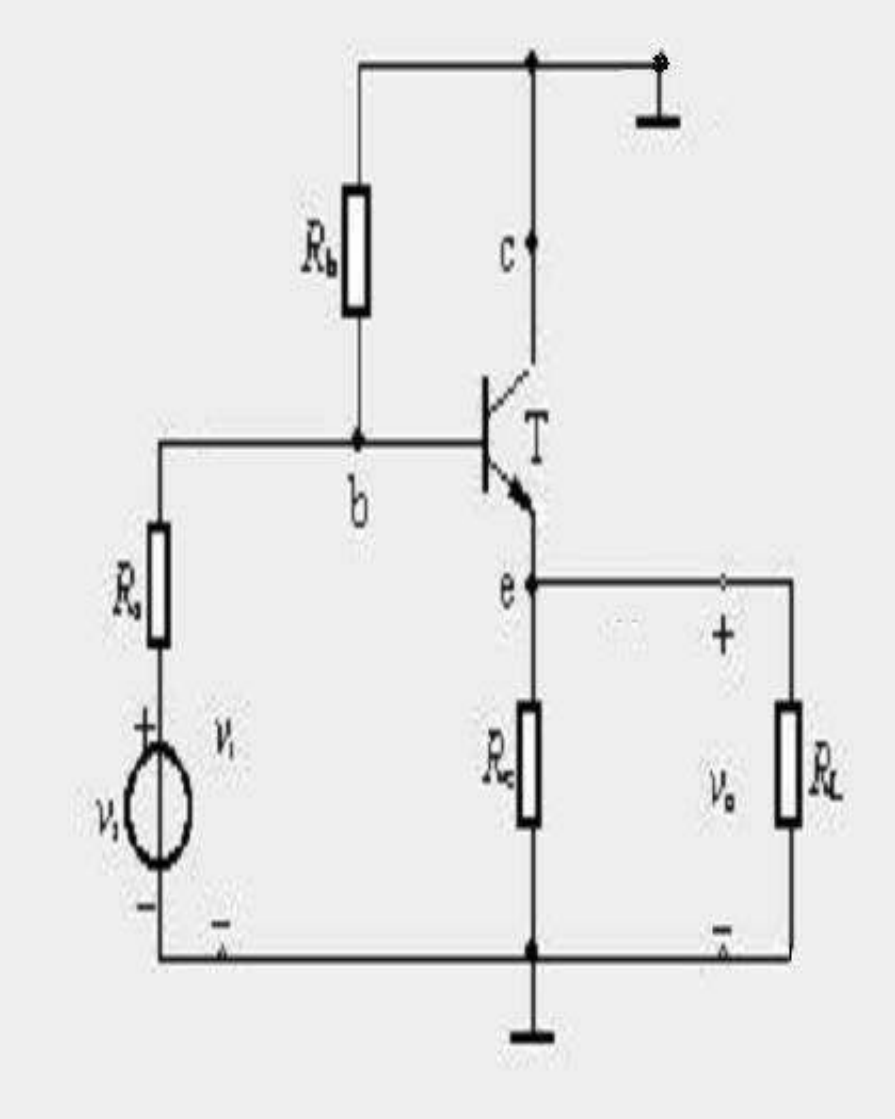


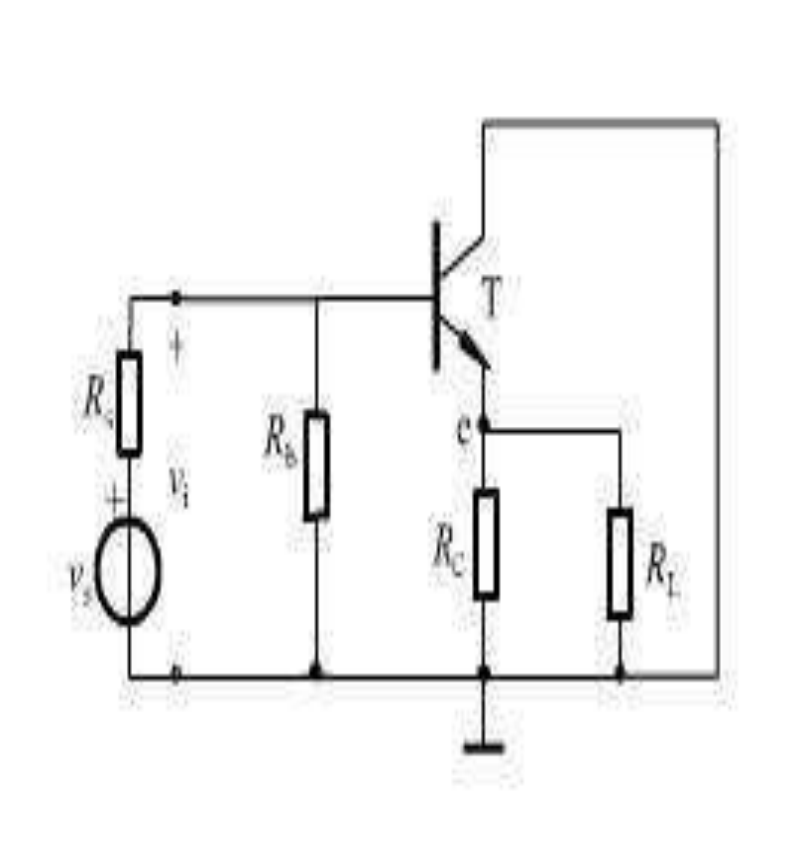

V_{cc}
R_b
c
T
b
e
R_s
v_s
v_i
R_c
v_o
R_L


V_{cc}
R_b
c
T
b
e
R_c

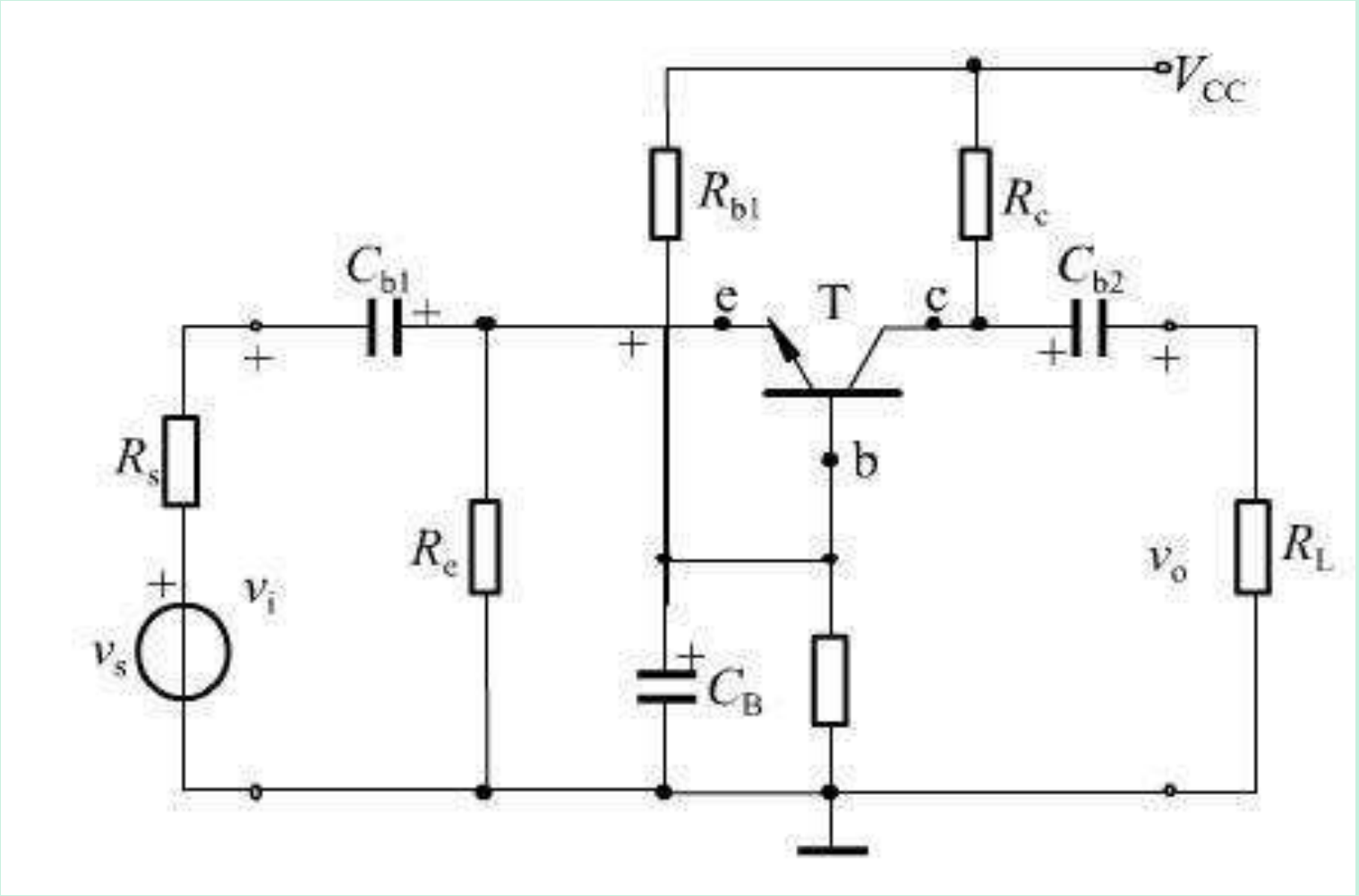

V_{CC}
R_b
c
T
b
e
R_s
v_s
v_i
R_c
v_o
R_L

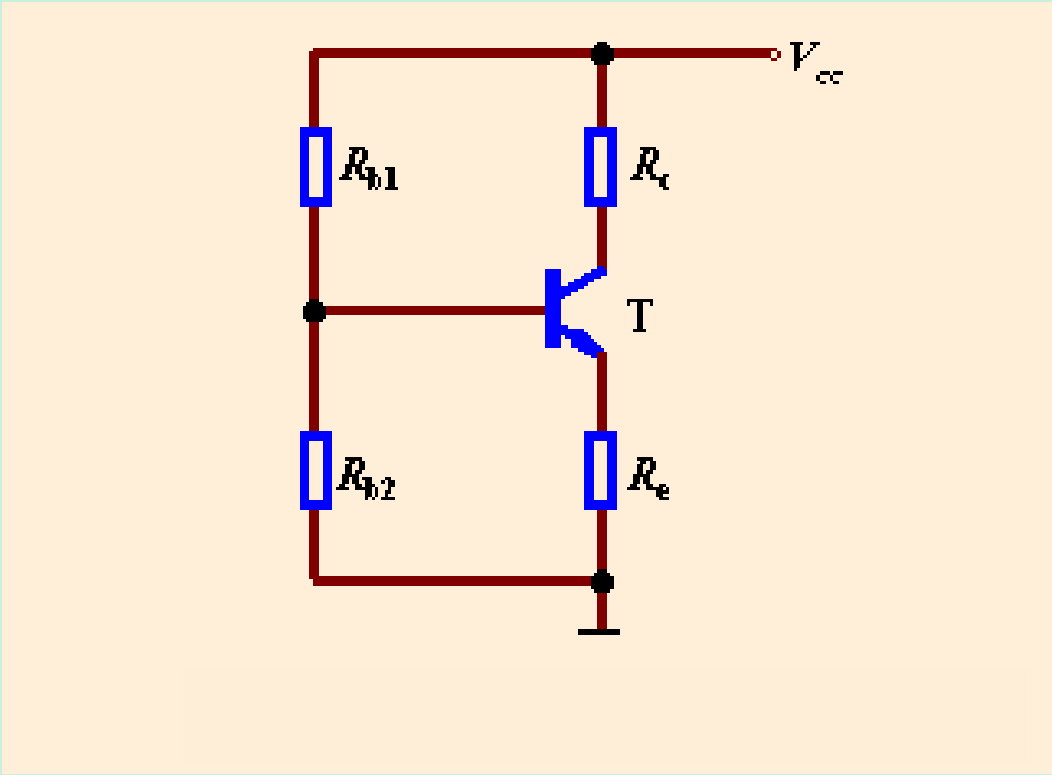

R_b
c
T
b
e
R_s
v_s
v_i
R_c
v_o
R_L

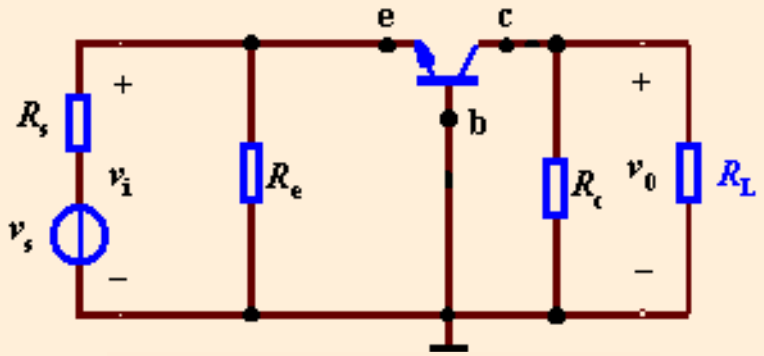

R_b
c
T
b
R_s
e
+
v_i
R_c
v_o
R_L
v_s
−


T
R_s
+
v_i
R_b
c
R_C
R_L
v_s

Sketch the DC circuit and AC Equivalent **circuit**



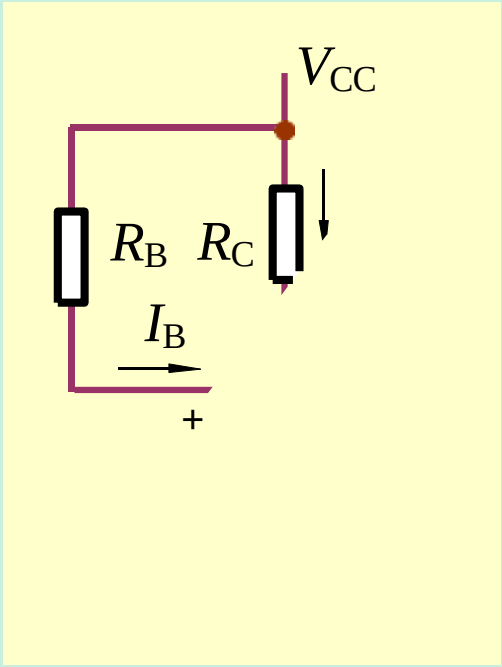

V_{cc}
R_{b1}
R_c
T
R_{b2}
R_e


e
c
b
+
R_s
v_i
v_s
–
R_e
R_c
+
v_0
–
R_L

5.2.3 Bipolar Transistor Biasing

1. Single base resistor biasing

- Determining Q-Point Using Approximation Equations



$$I_B = \frac{V_{BB} - V_{BE}}{R_B}$$

$$I_C = \beta$$

$$V_{CE} = V_{CC} - I_C R_C$$

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