Analog Electronic Circuits (UEC301)

By

Dr.Mayank Kumar Rai
Associate Professor,
ECED,TIET,Patiala

Thapar Institute of Engineering & Technology
(Deemed to be University)
Bhadson Road, Patiala, Punjab, Pin-147004
Contact No. : +91-175-2393201
Email : info@thapar.edu

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

Subject: Analog Electronic Circuits (UEC301)

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

Topic of today's Lecture : Methods of BJT Biasing

Key points

- ✓ **Base Resistor Method**
- ✓ **Feedback Resistor Method**
- ✓ **Voltage Divider Bias method(Self Bias)**

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.*

Methods of BJT Biasing

- ✓ Base Resistor Method
- ✓ Feedback Resistor Method
- ✓ Voltage Divider Bias method(Self Bias)

Methods of BJT Biasing

Base Resistor Method

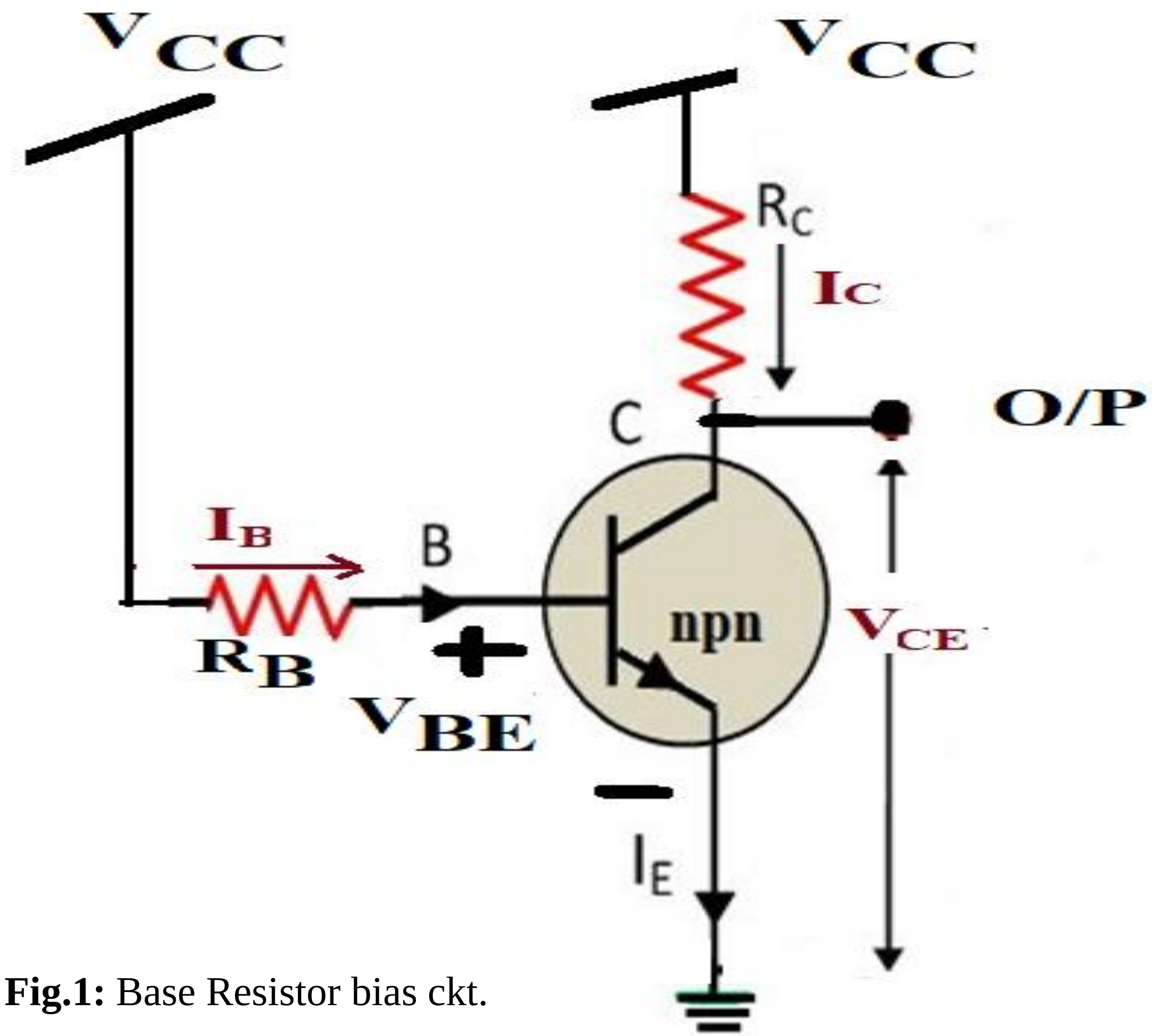


Fig.1: Base Resistor bias ckt.

Analysis of Base Resistor Circuit (I_B , I_C & V_{CE})

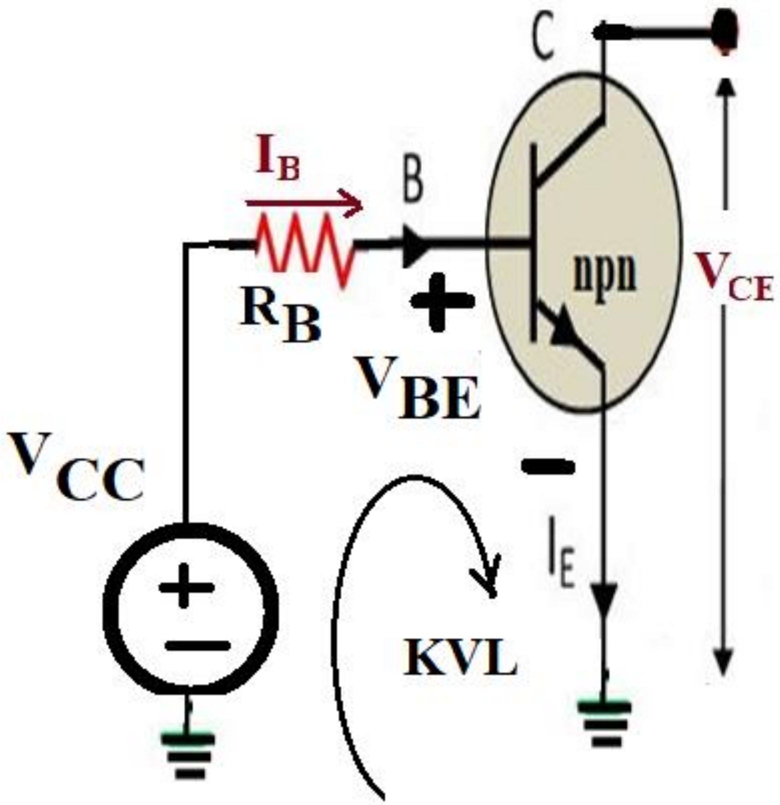


Fig.2: Redrawing the **i**nput side from Fig.1(Input Network)

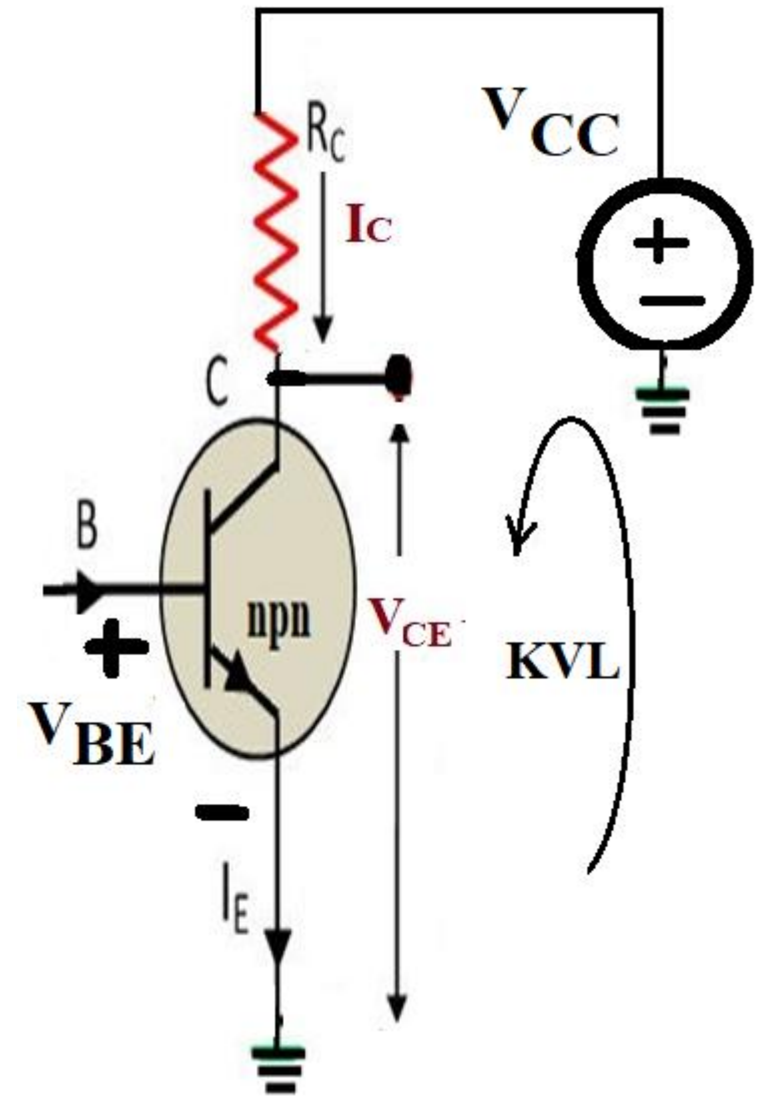


Fig.3: Redrawing the Output side from Fig.1(Output Network)

$$V_{CC} = V_{BE} + I_B R_B \text{ ....} \quad (1)$$

$$I_B = (V_{CC} - V_{BE}) / R_B \text{ ...} \quad (2)$$

$$I_C = \beta \, I_B \text{ ....} \quad (3)$$

$$V_{CE} = V_{CC} - I_C R_C \text{ ....} \quad (4)$$

Design of Base Resistor circuit (R_B & R_C)

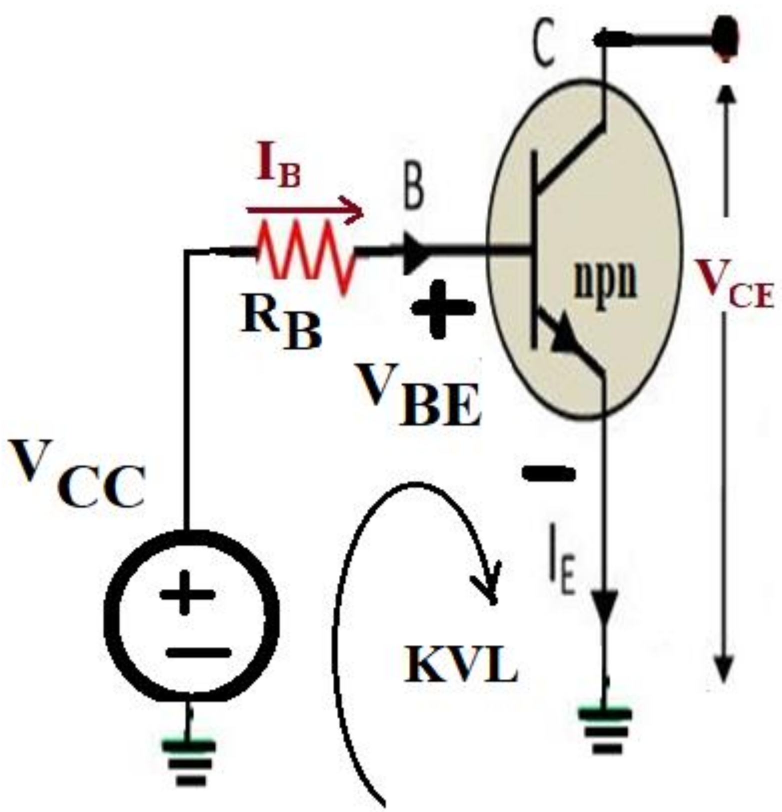


Fig.2: Input Network.

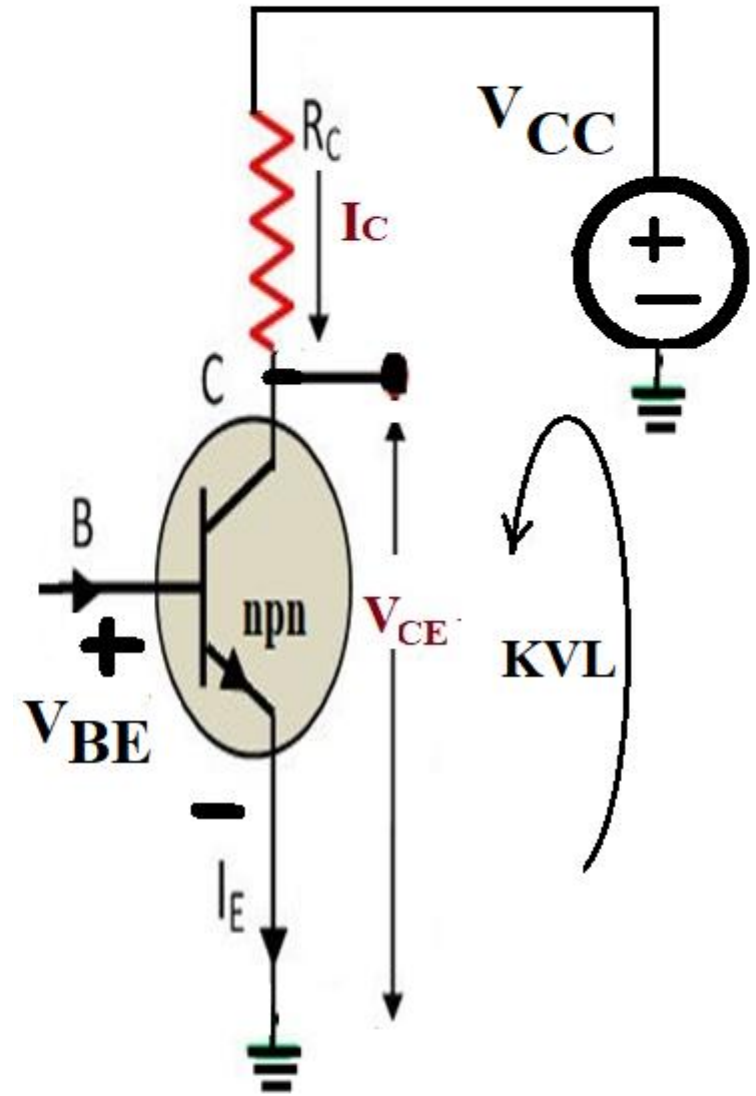


Fig.3: Output Network.

From Eq.(1)

$$R_B = (V_{CC} - V_{BE}) / I_B \ldots \quad (5)$$

From Eq.(4)

$$R_C = (V_{CE} - V_{CC}) / I_C \ldots \quad (6)$$

Feedback Resistor Method

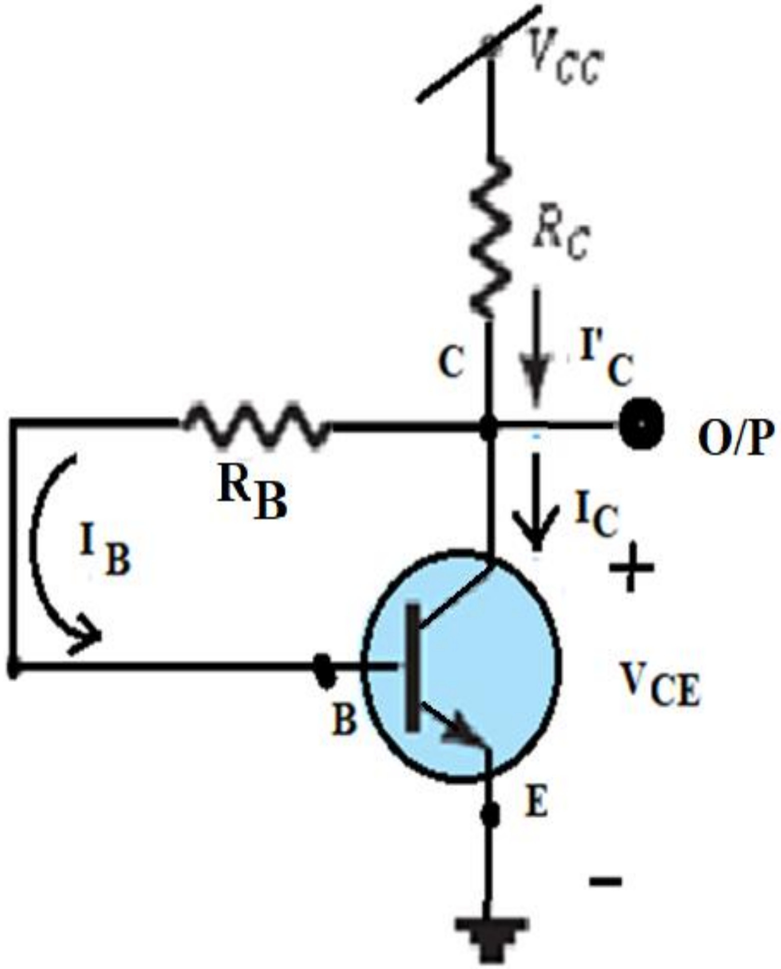


Fig.4: Feedback Resistor ckt.

Analysis(I_B, I_C & V_{CE})

$V_{CE} = V_{BE} + V_{CB}$ ..... (7)

$V_{CB} = V_{CE} - V_{BE}$ .... (8)

$I_B = V_{CB} / R_B$ .... (9)

$I_C = \beta I_B$ .... (10)

$V_{CE} = V_{CC} - I_C R_C$ ..... (11)

Design of Feedback Resistor circuit

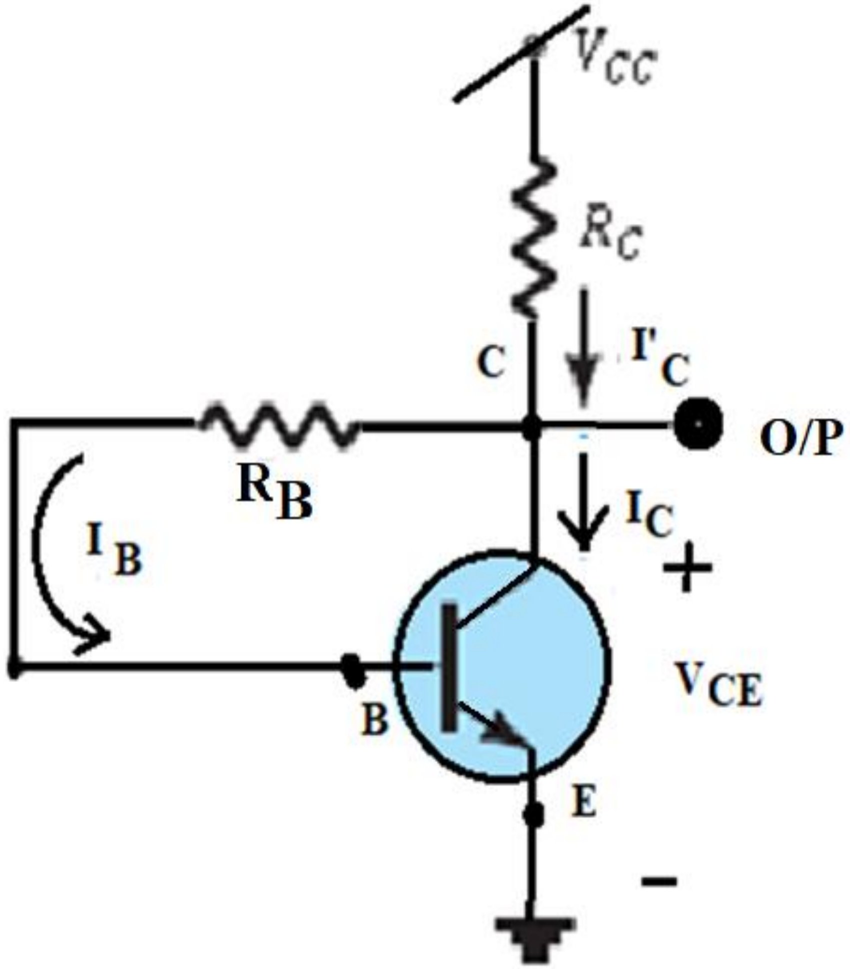


Fig.4: Feedback Resistor ckt.

Design(R_B &R_C)

From Eq.(9)

$\mathbf{R_B = V_{CB}/ I_B}$ **......... (12)**

From Eq.(11)

$\mathbf{R_C = (V_{CE} - V_{CC})/I_C}$**.... (13)**

Cont...

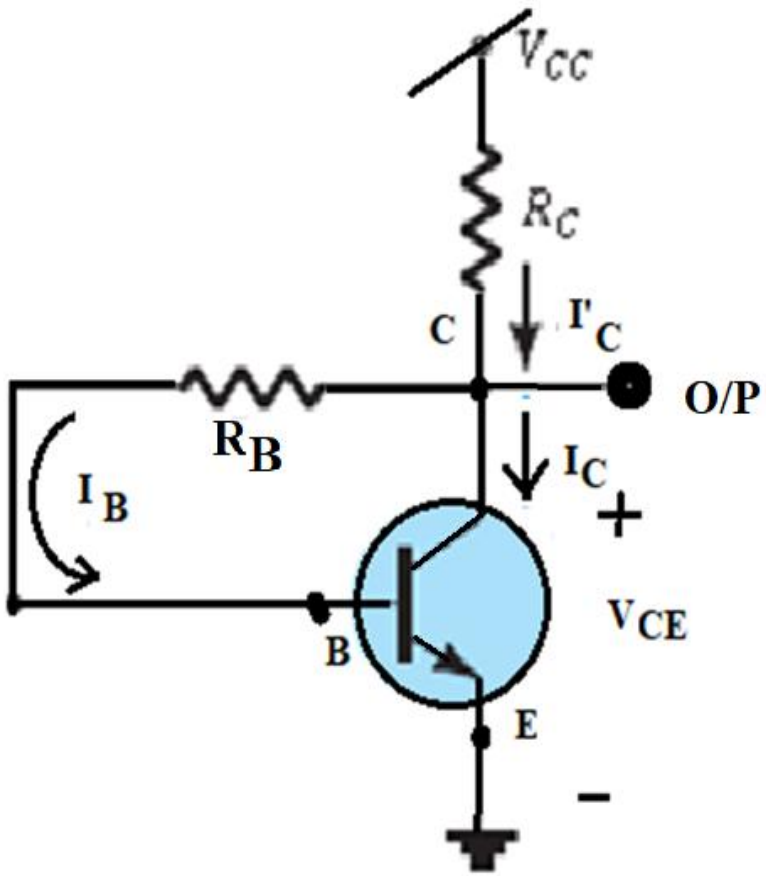
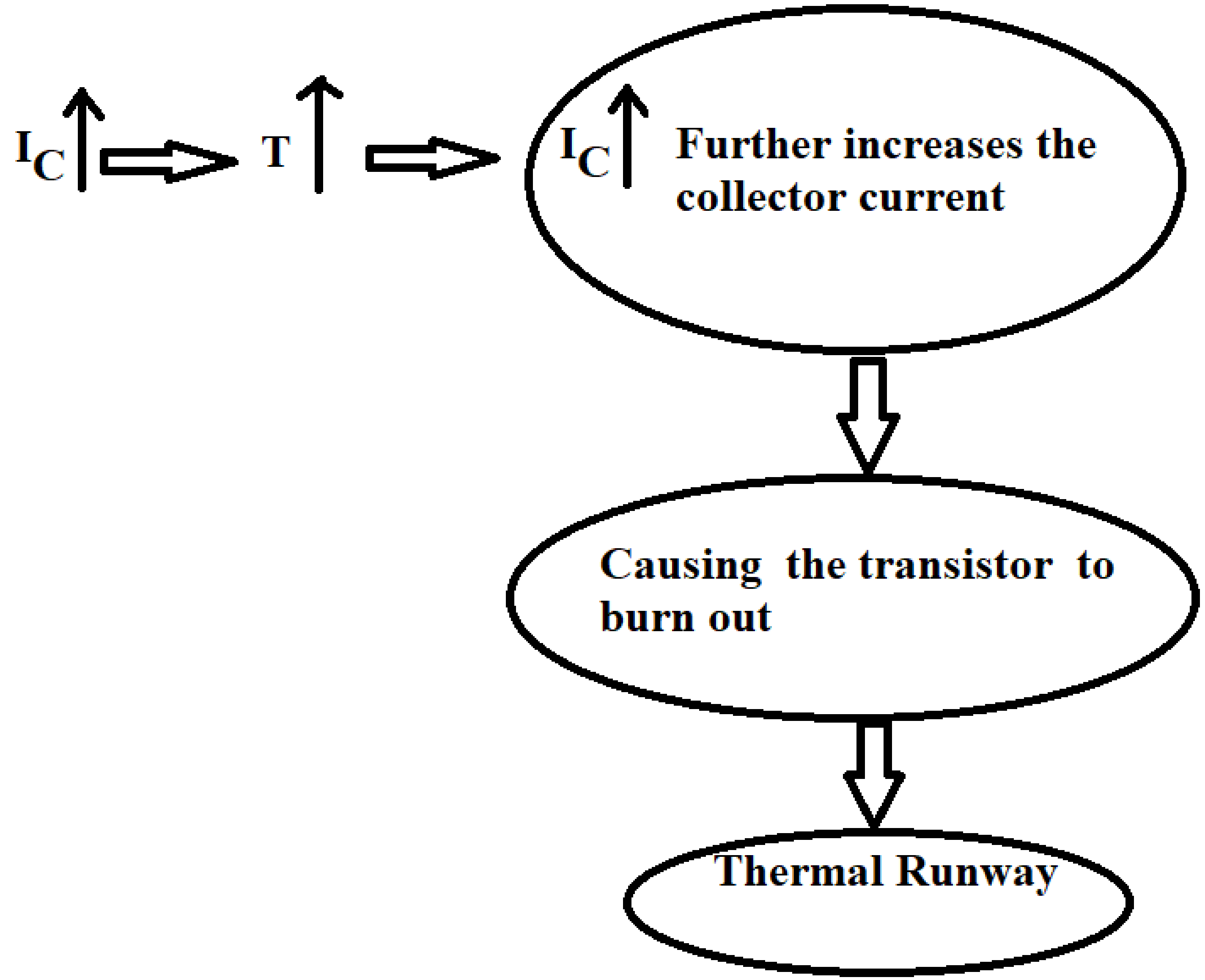


Fig.4: Feedback Resistor ckt.



Voltage Divider Bias Method (Self Bias)

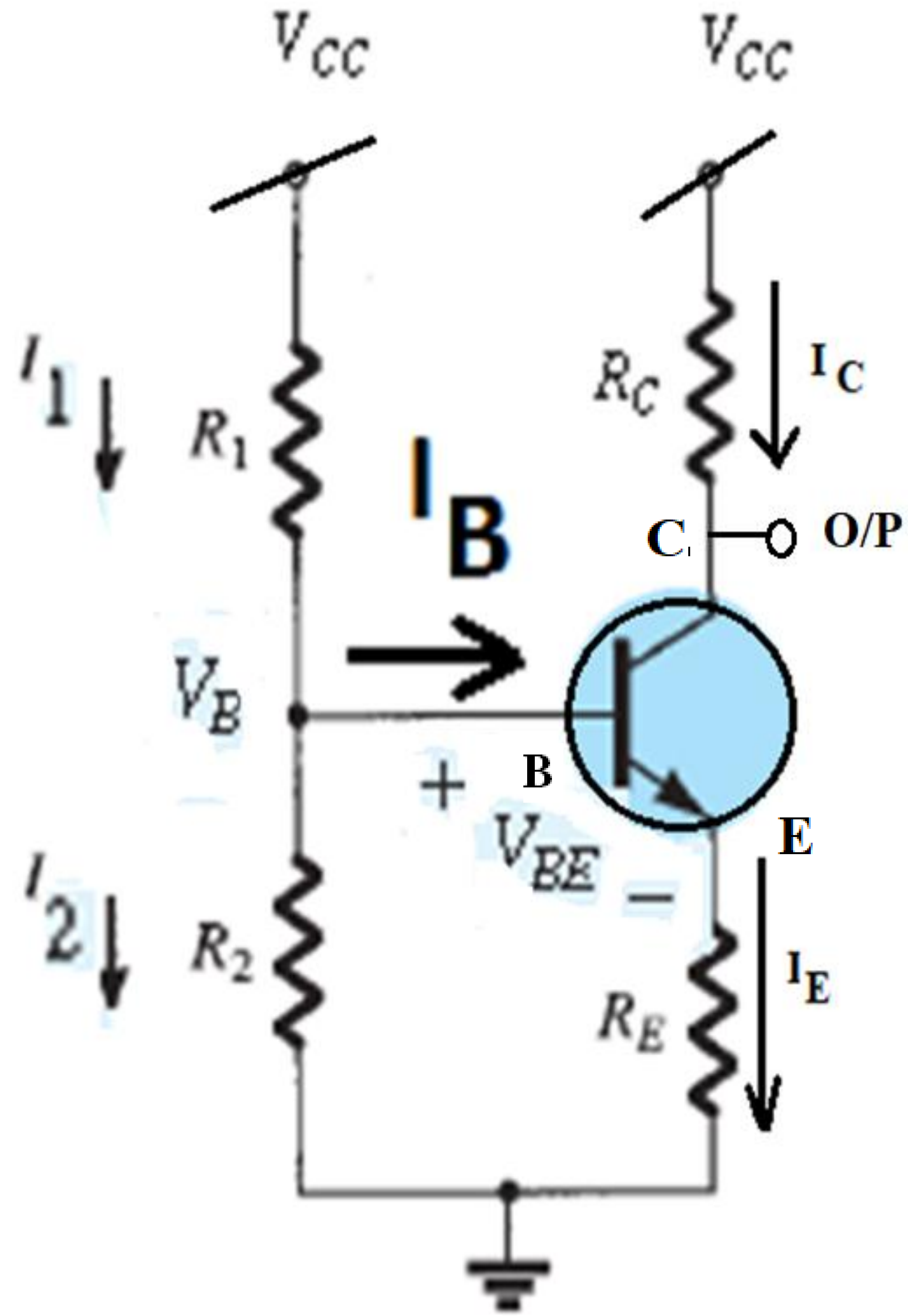


Fig.5: Voltage Divider Bias ckt.

Analysis(I_C & V_{CE})

- ✓ **Approximation Method**
- ✓ **Exact Method**

Emitter resistance

$$I_C \uparrow \Rightarrow \boxed{I_C + I_B} \uparrow \Rightarrow V_E \uparrow (= I_E R_E)$$

$$\Downarrow$$

$$\downarrow I_C \Leftarrow \downarrow I_B \Leftarrow V_{BE} \downarrow$$

$$\Downarrow I_E = (V_B - V_{BE})/R_E \Uparrow$$

$$\Downarrow$$

$$\Downarrow I_E \cong I_C \Downarrow$$

Approximation Method

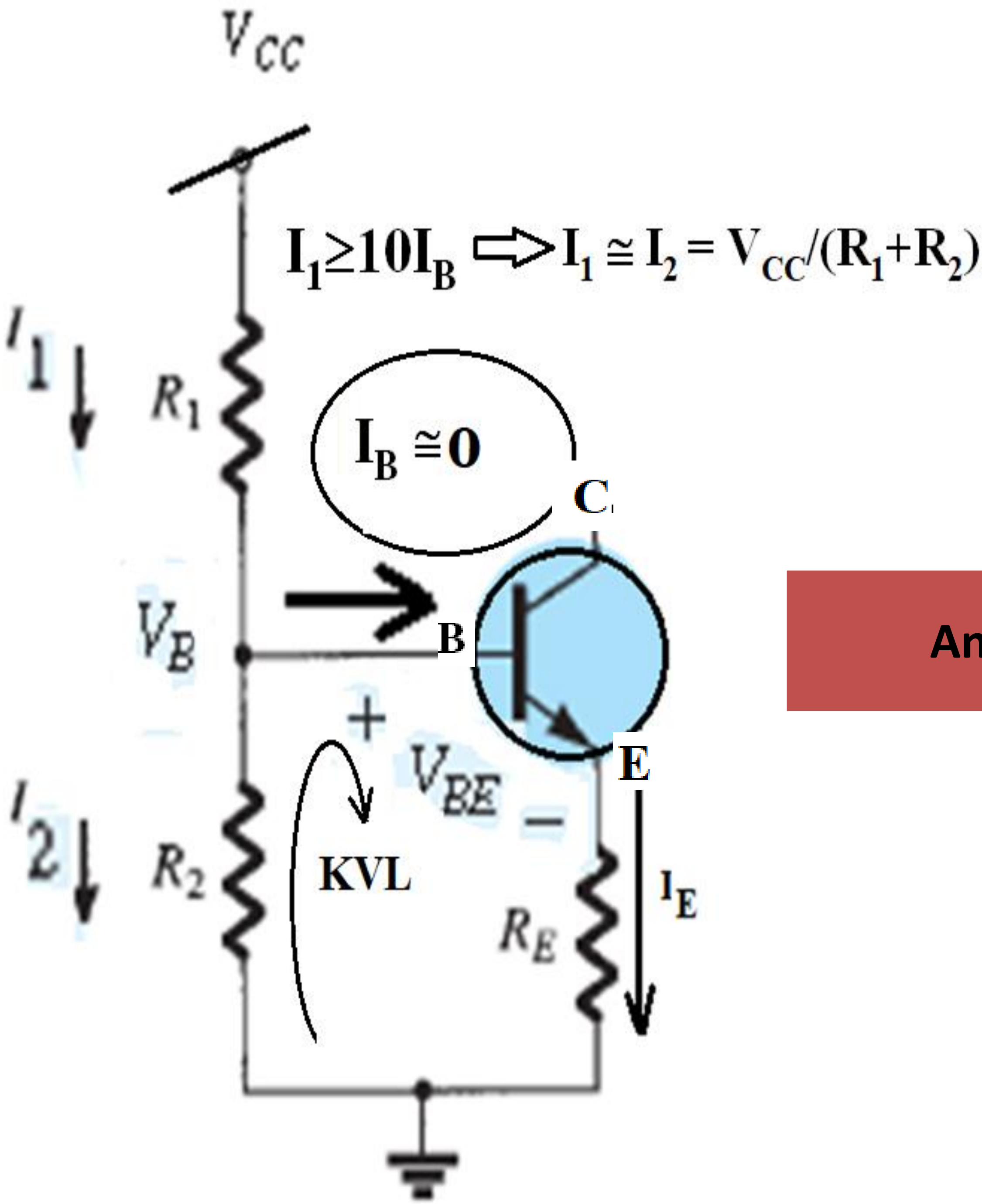


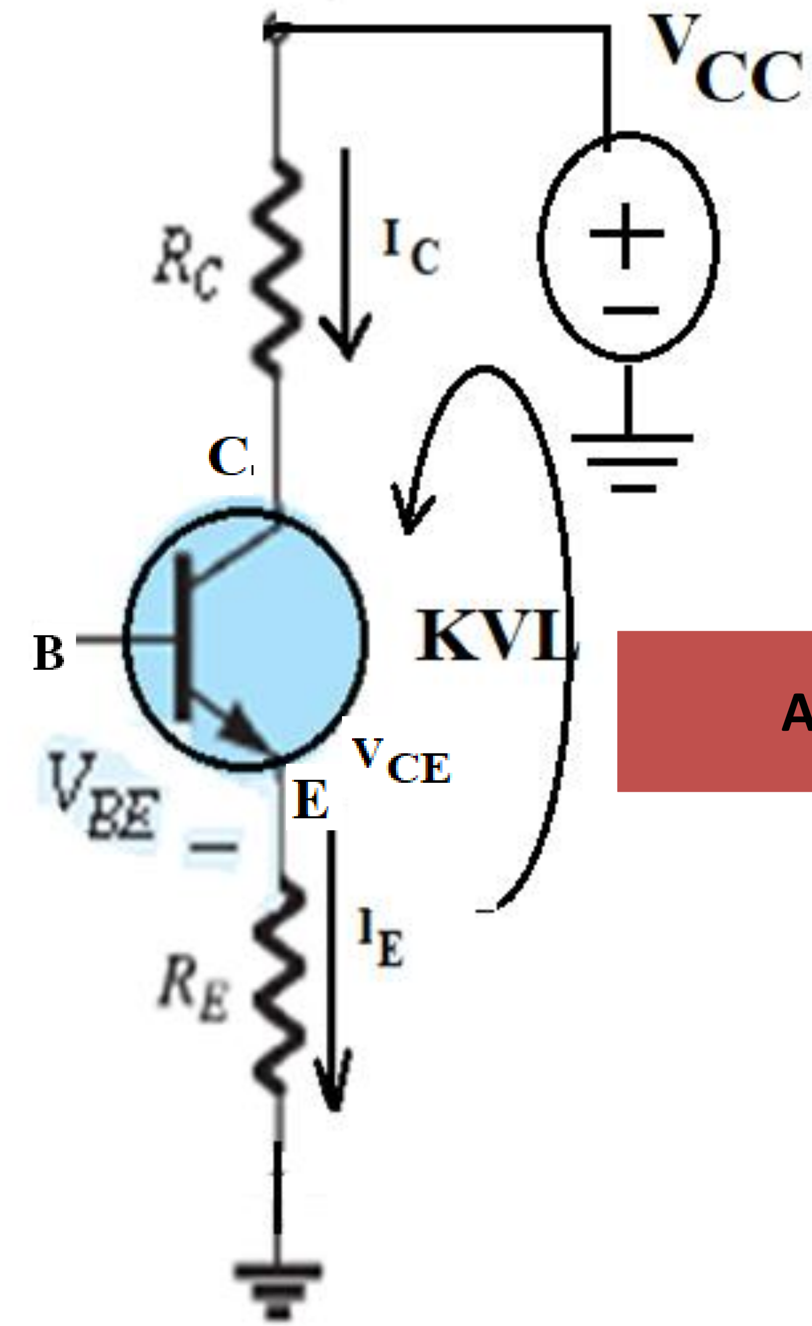
Fig.6: Input Network.

Analysis(I_C & V_{CE})

$V_B = (R_2\ V_{CC})/R_1+R_2$ ....(14)

$V_B = I_E\ R_E + V_{BE}$ ....(15)

$I_E = V_E/R_E = (V_B - V_{BE})/R_E$ ......(16)



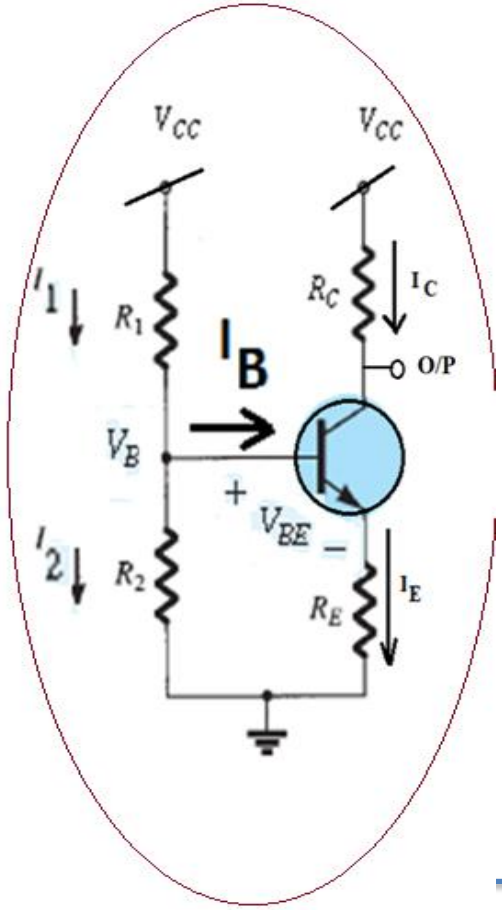
Analysis(I_C & V_{CE})

$$I_C \cong I_E \quad \text{..........(17)}$$

$$V_{CE} = V_{CC} - I_C(R_C + R_E) \quad \text{.......(18)}$$

Fig.7: Output Network.

Exact Method



Analysis(I_C & V_{CE})

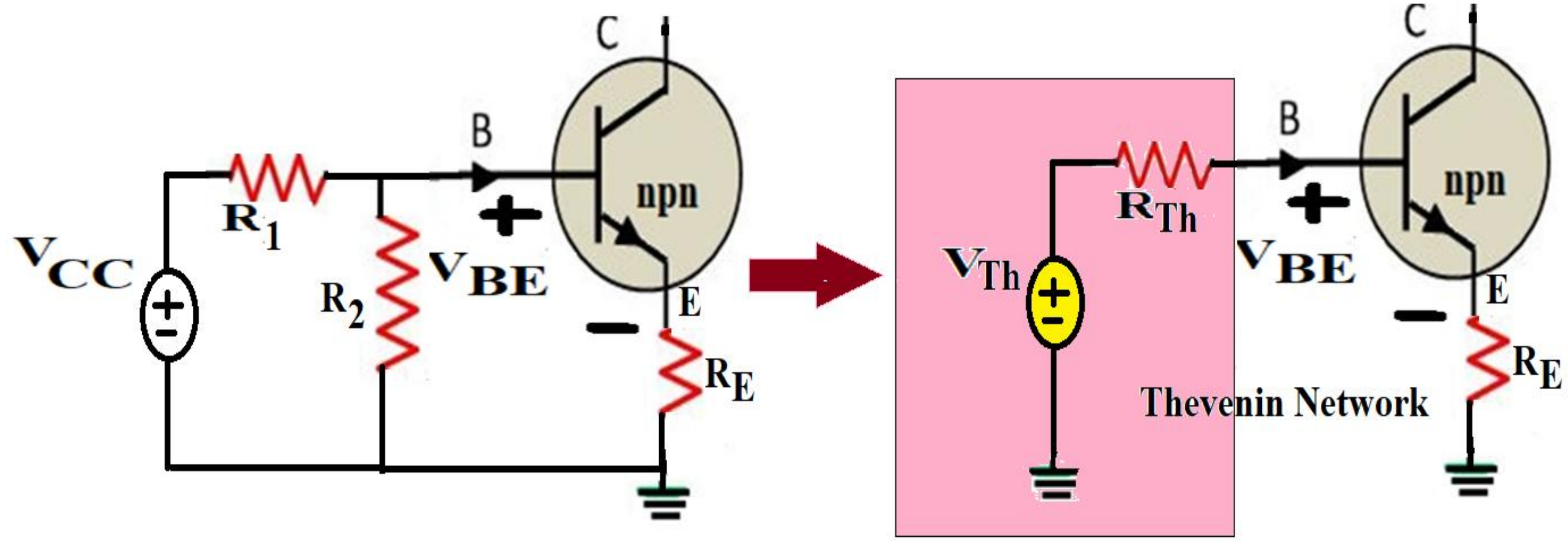
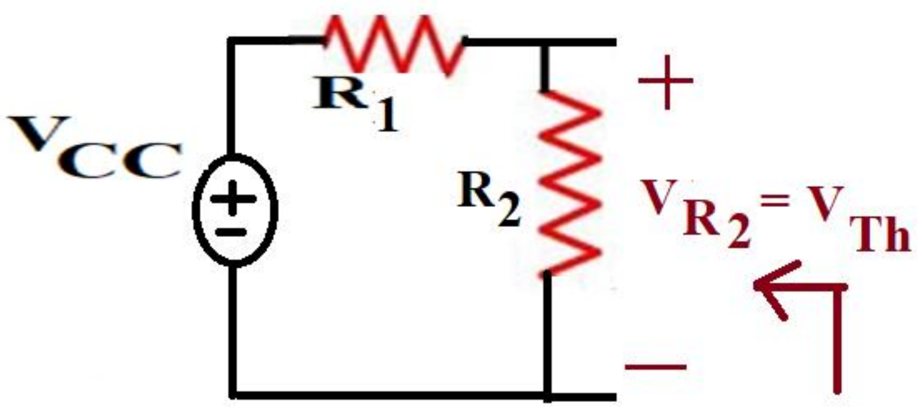
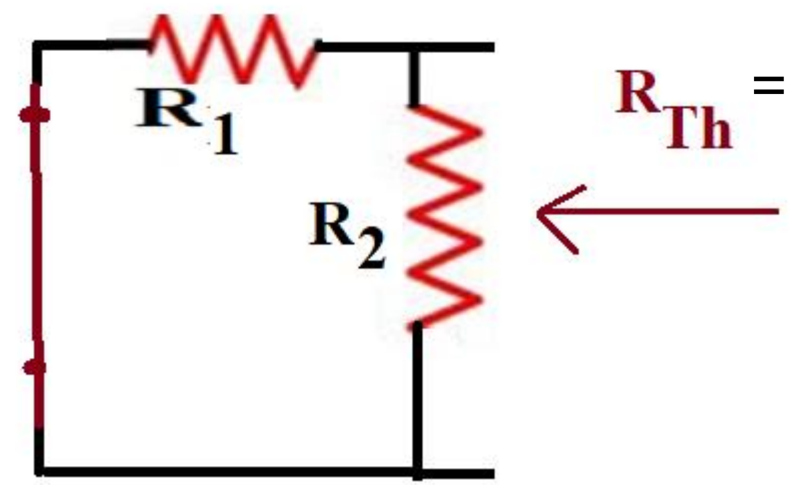


Fig. 7: Redrawing the input side of voltage divider ckt.



$= (R_2\ V_{CC})/R_1+R_2$

Fig. 8: Determining V_{Th}.



$R_{Th} = (R_1\ R_2)/R_1+R_2$

Fig. 9: Determining R_{Th}.

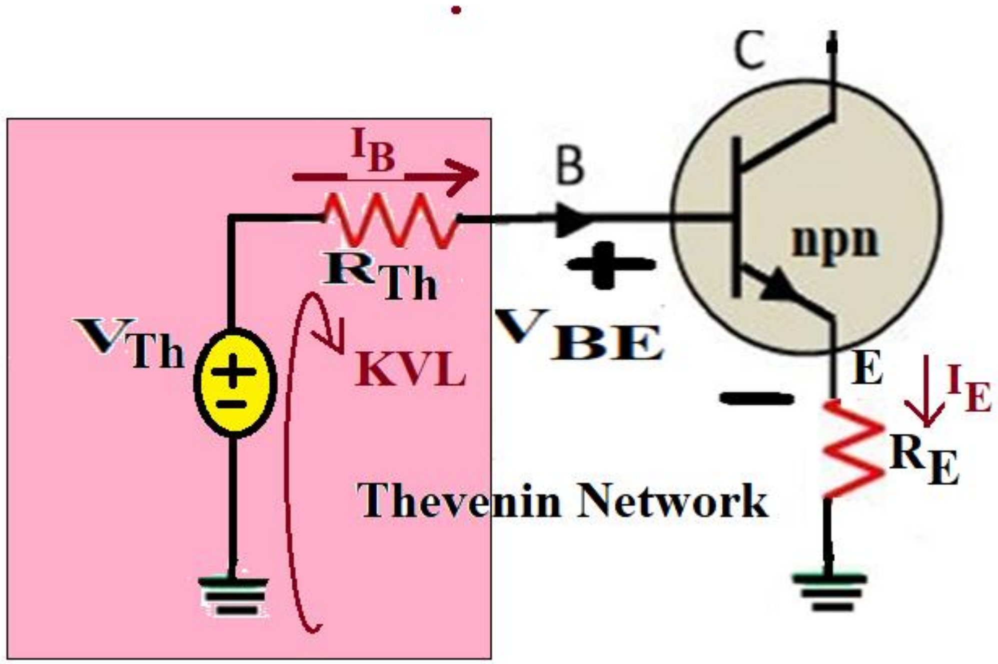


Fig. 10: Input Network.

$$V_{Th} = I_B\,R_{Th} + V_{BE} + I_E\,R_E \;\ldots\ldots\ldots\ldots\ldots\ldots(19)$$

$$I_B = V_{Th} - V_{BE}\,/\{(R_{Th} + (1+\beta)R_E\}\ldots(20)$$

$$I_C = \beta\, I_B \qquad \ldots\ldots\ldots\ldots\ \ldots\ldots\ldots\ldots\ldots(21)$$

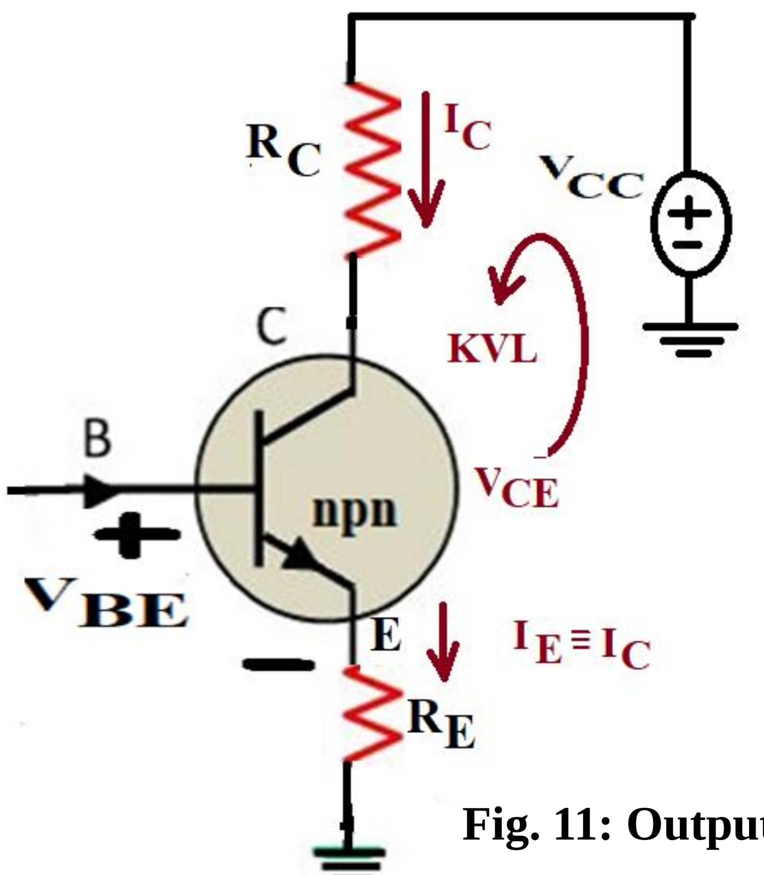
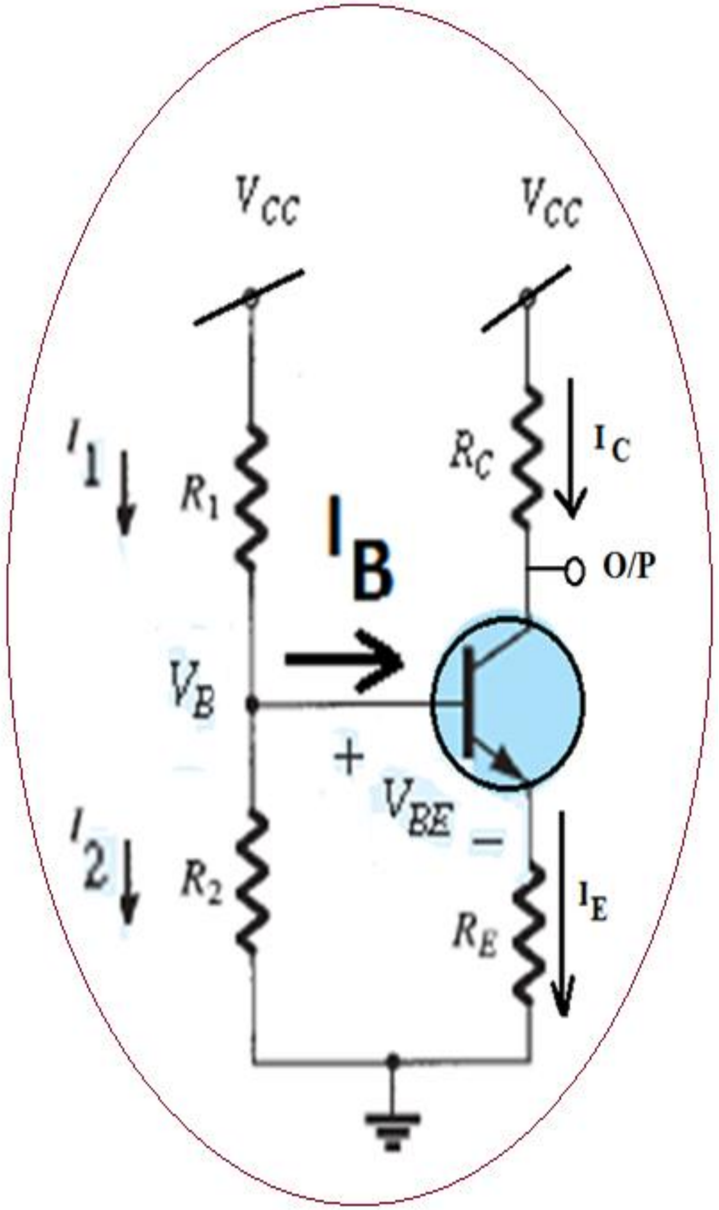


Fig. 11: Output Network.

$$I_C \cong I_E \qquad \ldots\ldots\ldots\ldots\ldots(22)$$

$$V_{CE} = V_{CC} - I_C\,(R_C + R_E) \;\ldots\ldots\ldots\ldots(23)$$

Design of Voltage Divider bias Circuit



From Fig.5

(R_E, R_1, & R_2)

The following steps are taken:

Step 1: from Eq.(23)

$$R_E = (V_{CC} - V_{CE} - I_C R_C)/I_C \quad \ldots\ldots(24)$$

Step 2:

The values of resistance R_1 and R_2 are selected so that the current I_1 flowing through R_1 and R_2 is at least 10 times I_B $I_1 \geq 10 I_B$

$$I_1 \cong I_2 = V_{CC}/(R_1+R_2)$$

$$R_2 = V_B / I_1 \quad \ldots(25), \qquad \text{where } V_B = I_E R_E + V_{BE}$$

$$R_1+R_2 = V_{CC} / I_1 \quad \ldots\ldots(26)$$

$$R_1 = V_{CC} / I_1 - R_2 \ldots\ldots(27)$$

Thank You