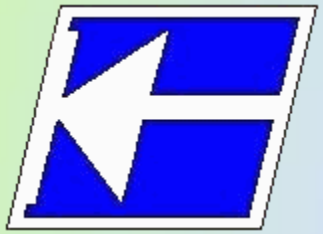
Instituto Federal de Educação, Ciência e Tecnologia de Santa Catarina
Departamento Acadêmico de Eletrônica
Eletrônica Básica e Projetos Eletrônicos



Polarização de transistores bipolares de junção

Prof. Clóvis Antônio Petry.

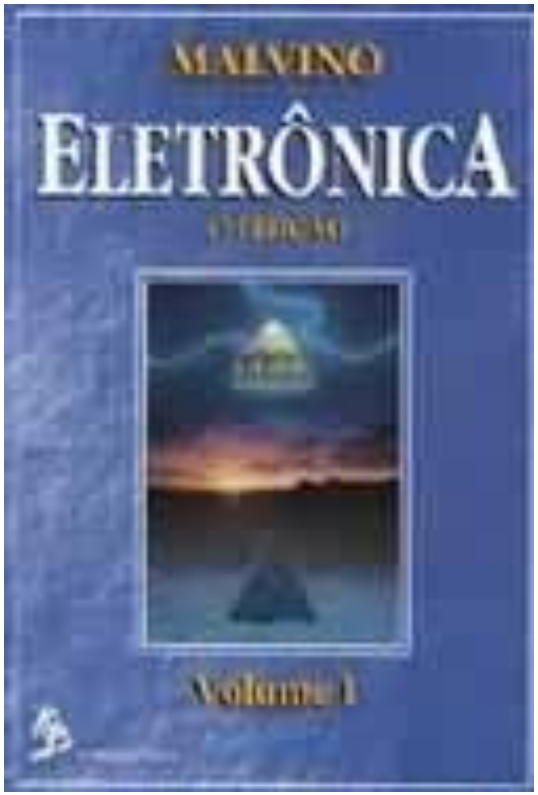
Florianópolis, abril de 2009.

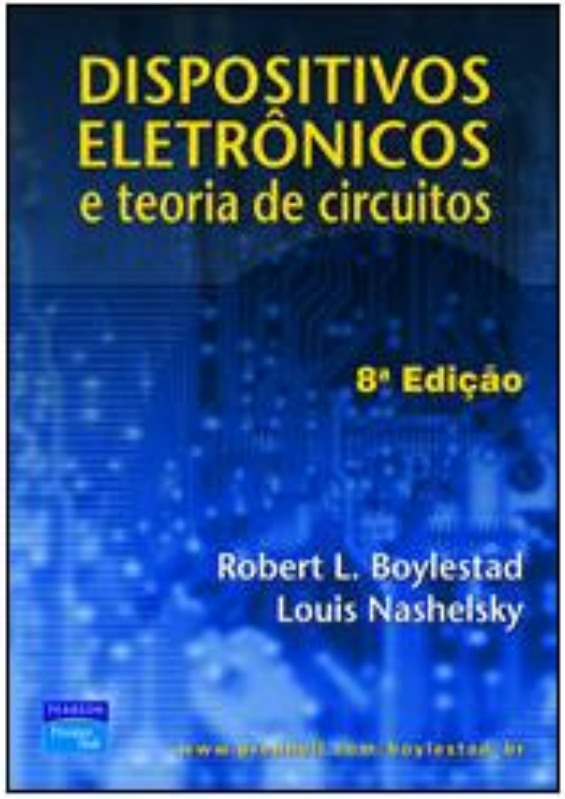
Nesta aula

Seqüência de conteúdos:

1. Introdução;
2. Ponto de operação;
3. Circuito de polarização fixa;
4. Aplicações;
5. Exercícios.
6. Circuitos com transistores:
    - Amplificador com polarização fixa;
    - Amplificador com estabilização de emissor;
    - Amplificador com polarização por divisor de tensão;
    - Fonte de corrente constante;
    - Sistema de alarme;
    - Espelho de corrente;
    - Polarização de transistor PNP;
    - Oscilador controlado a cristal;
    - Amplificador operacional 741;
    - Multivibrador monoestável;
    - Multivibrador astável.

Bibliografia





Introdução

Relações básicas no transistor:

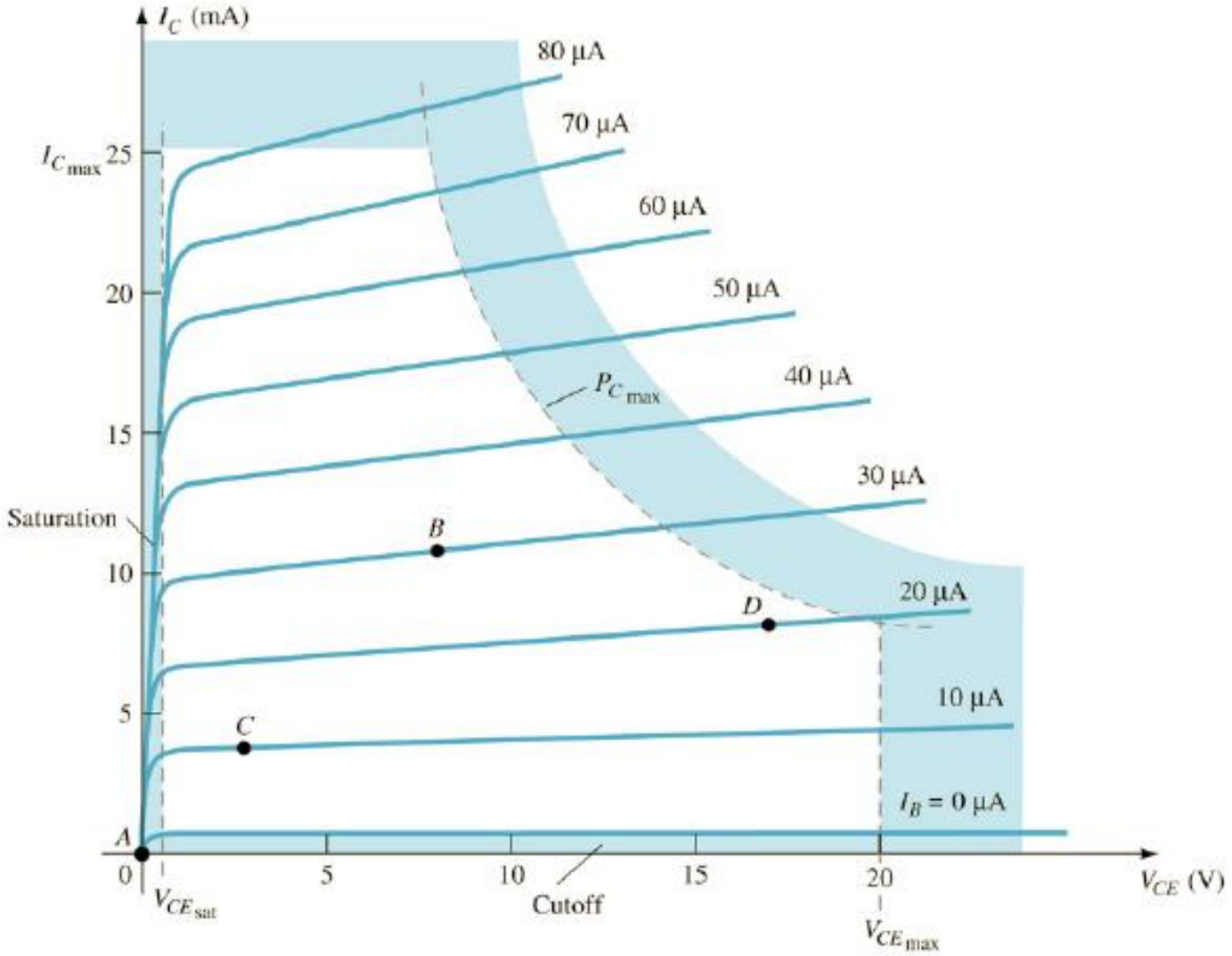
- Tensão base-emissor;
- Corrente de emissor;
- Corrente de coletor;
- Ganho.

$$V_{BE} = 0,7V$$

$$I_E = (\beta + 1) \cdot I_B \cong I_C$$

$$I_C = \beta \cdot I_B$$

Ponto de operação



Ponto de operação

Operação na região linear (ativa):

- Junção base-emissor polarizada diretamente;
- Junção base-coletor polarizada reversamente.

ON

Operação na região de corte:

- Junção base-emissor polarizada reversamente;
- Junção base-coletor polarizada reversamente.

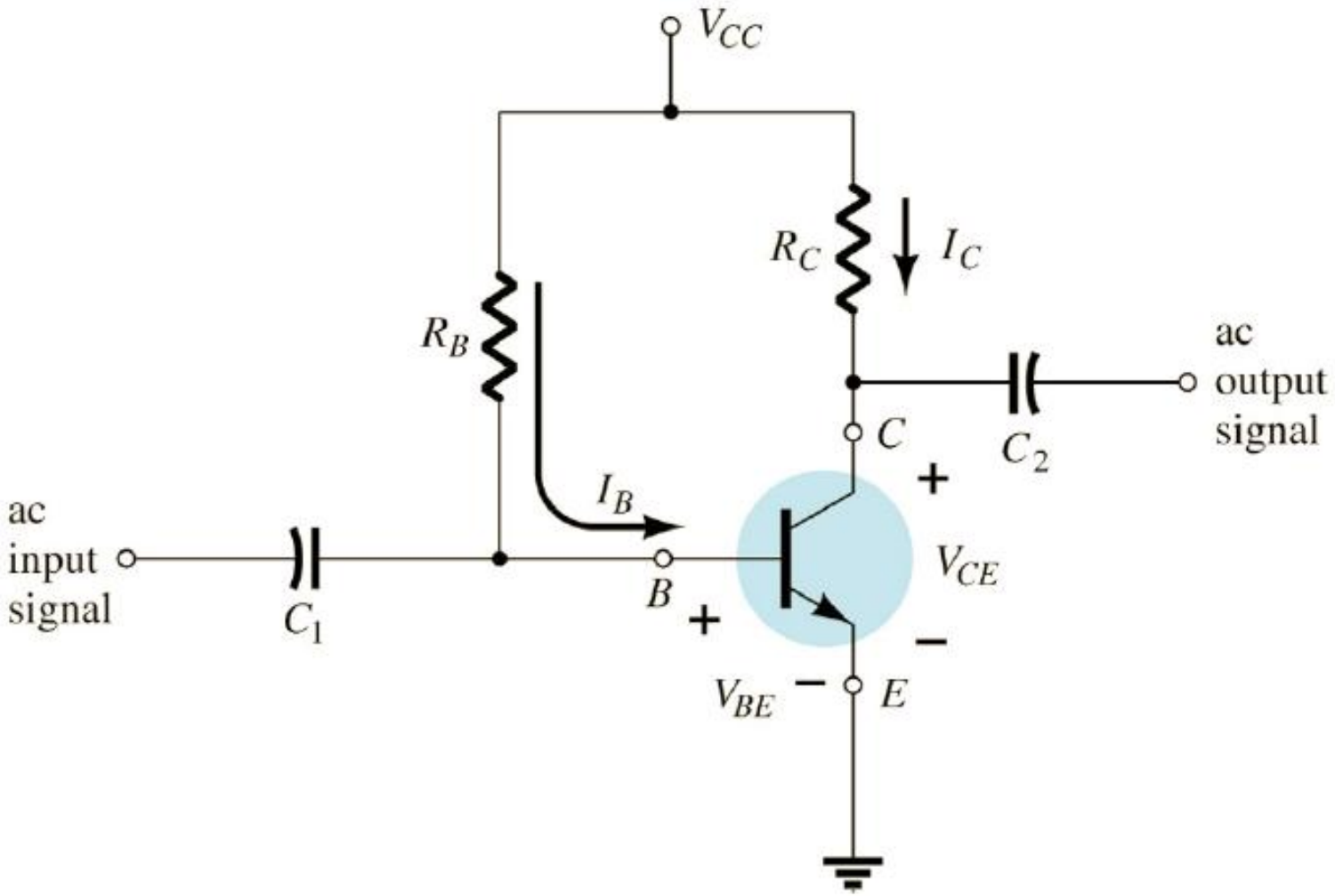
OFF

Operação na região de saturação:

- Junção base-emissor polarizada diretamente;
- Junção base-coletor polarizada diretamente.

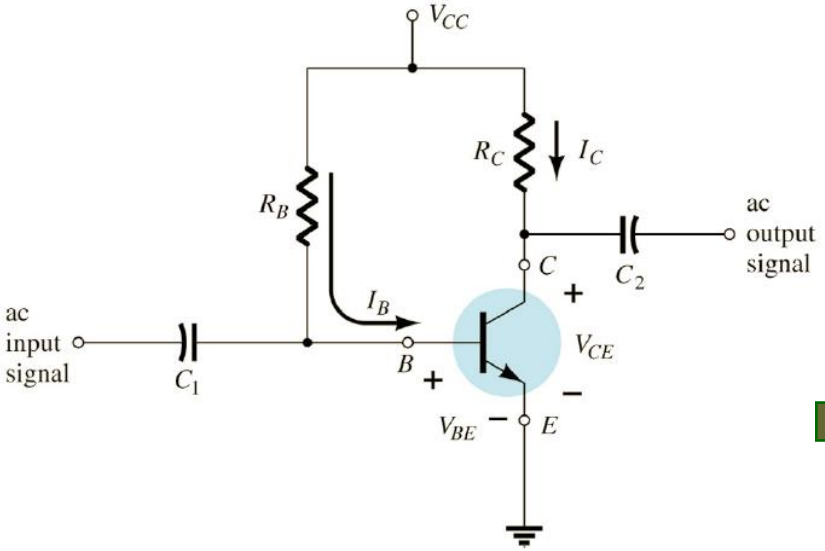
ON

Circuito com polarização fixa

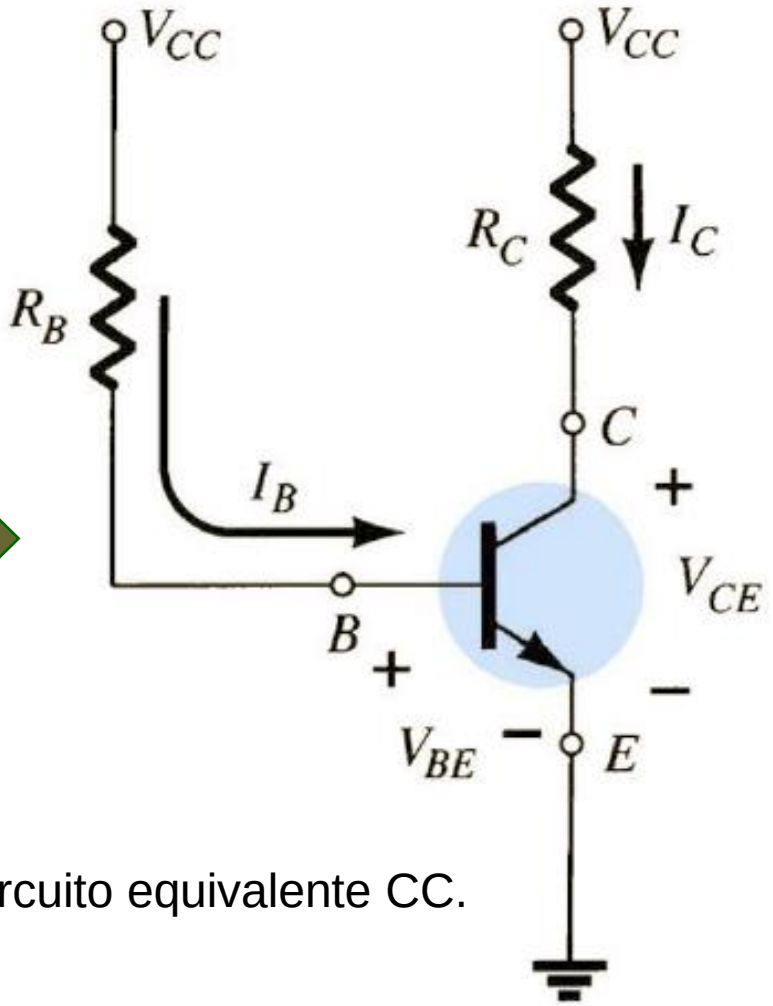


Exemplo de um amplificador transistorizado com polarização fixa.

Circuito com polarização fixa



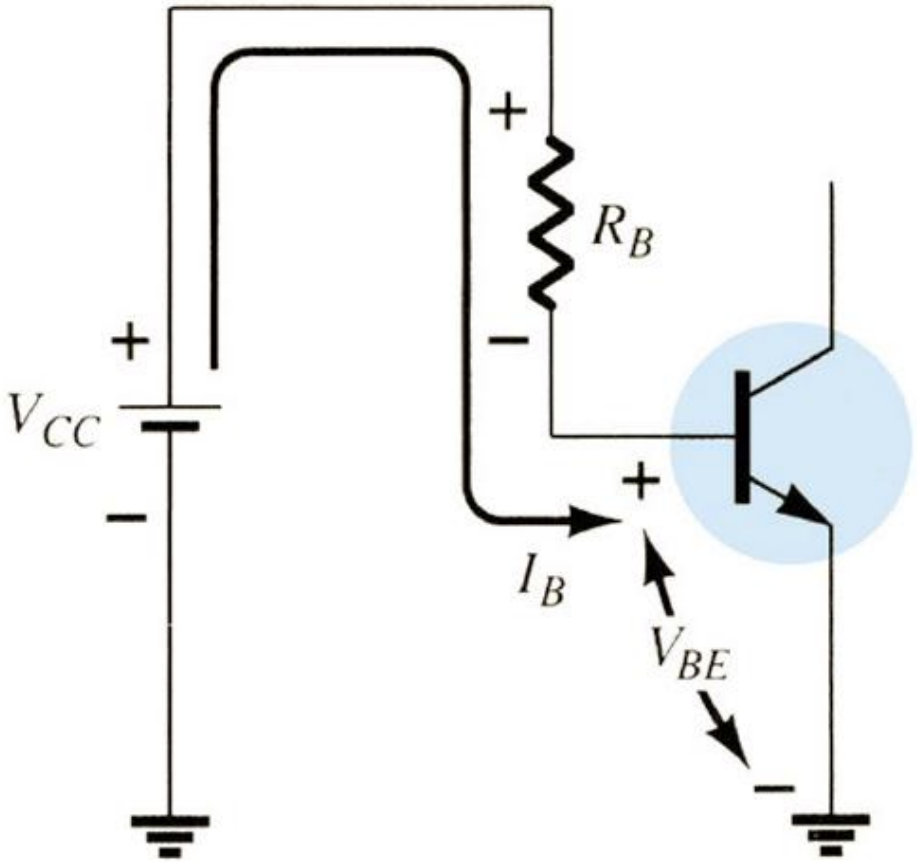
Circuito completo CC + CA.



Circuito equivalente CC.

Circuito com polarização fixa

Polarização direta da junção base-emissor:

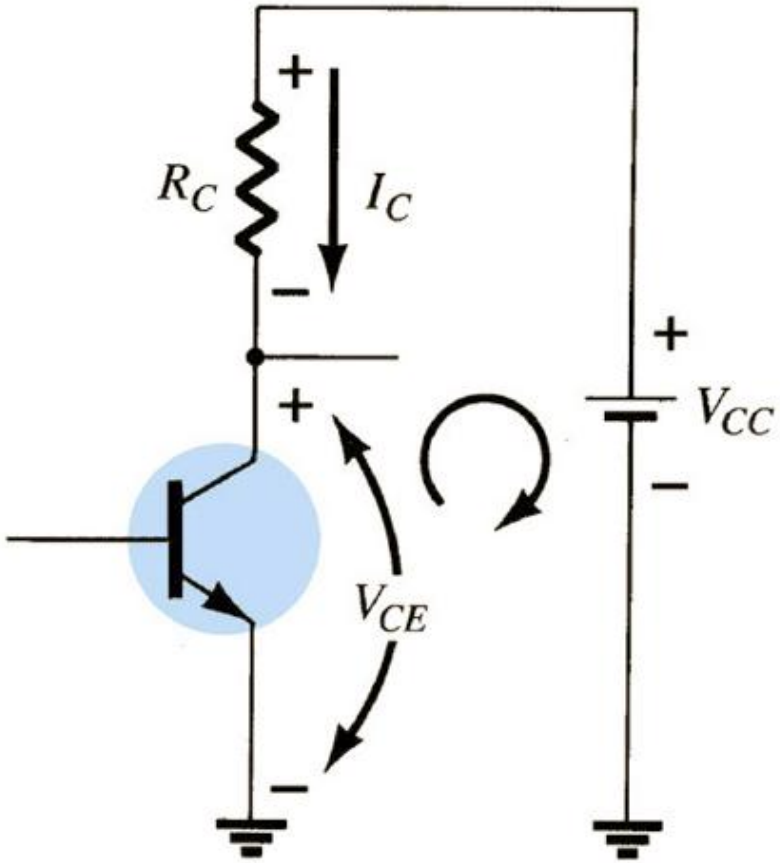


$$+V_{CC} - I_B \cdot R_B - V_{BE} = 0$$

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

Circuito com polarização fixa

Malha coletor-emissor:



$$I_C = \beta \cdot I_B$$

$$V_{CE} + I_C \cdot R_C - V_{CC} = 0$$

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

Circuito com polarização fixa

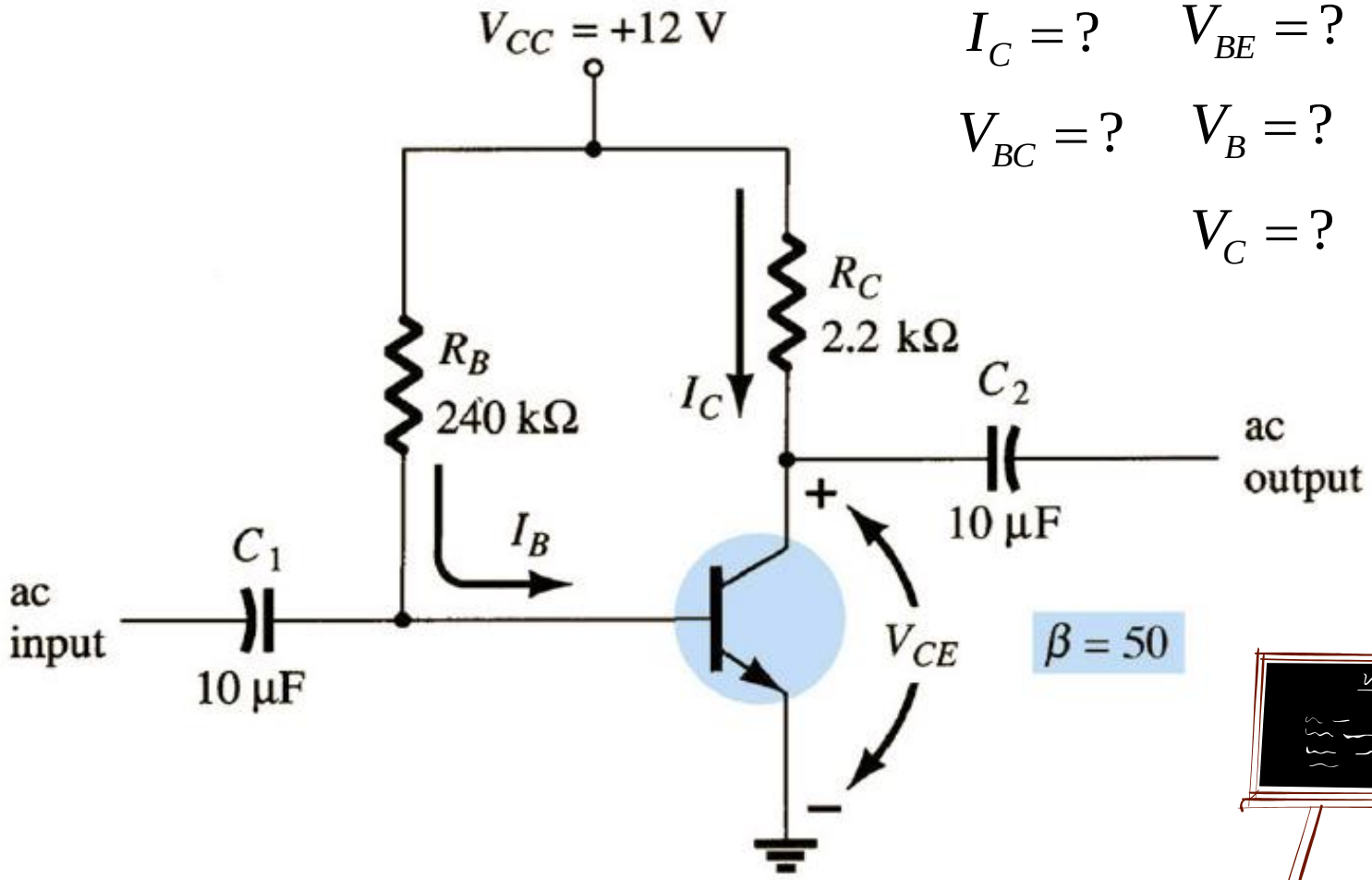
Exemplo:

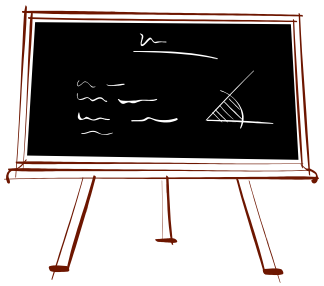
$I_B = ?$ $V_{CE} = ?$

$I_C = ?$ $V_{BE} = ?$

$V_{BC} = ?$ $V_B = ?$

$V_C = ?$





Circuito com polarização fixa

Exemplo:

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{12 - 0,7}{240k} = 47,08\,\mu A$$

$$I_C = \beta \cdot I_B = 50 \cdot 47,08\mu = 2,35mA$$

$$V_{CE} = V_{CC} - I_C \cdot R_C = 12 - 2,35m \cdot 2,2k = 6,83V$$

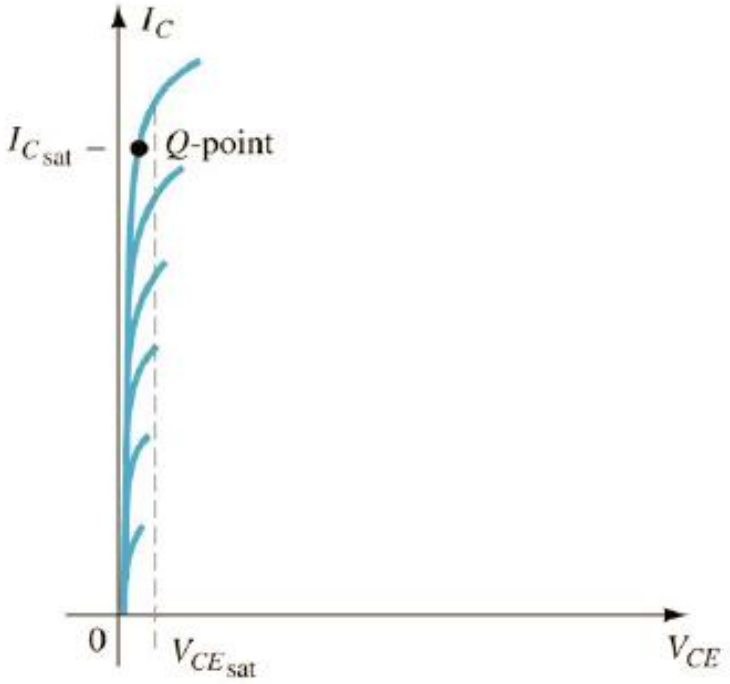
$$V_{BE} = V_B = 0,7V$$

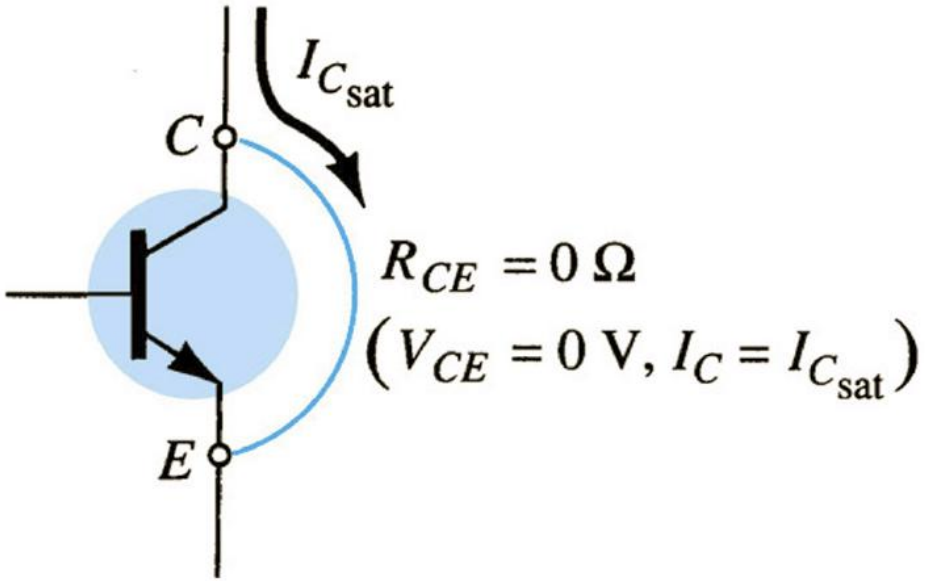
$$V_{CE} = V_C = 6,83V$$

$$V_{BC} = V_B - V_C = 0,7 - 6,83 = -6,13V$$

Circuito com polarização fixa

Saturação do transistor:

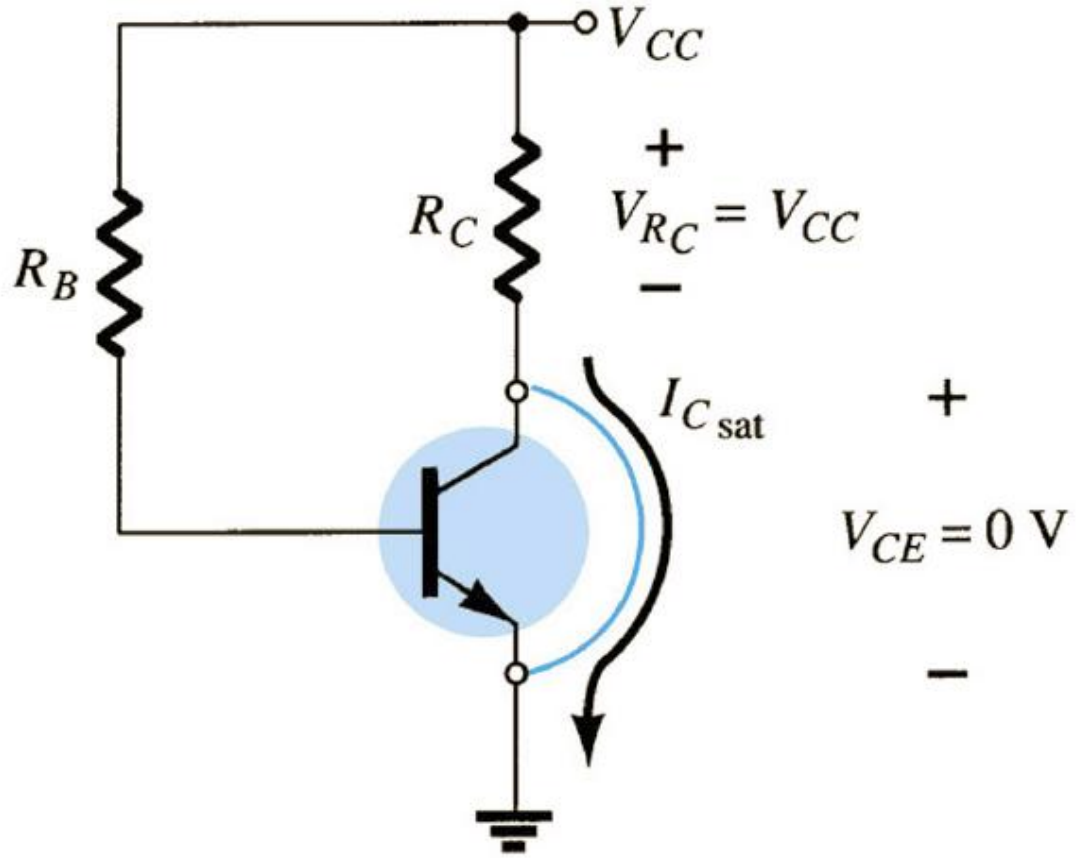




$$I_{Csat} = \frac{V_{CC}}{R_C}$$

Circuito com polarização fixa

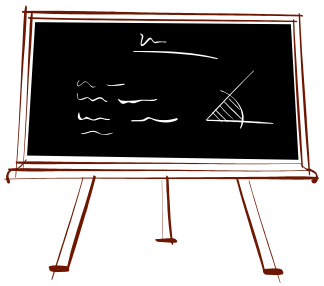
Saturação do transistor, exemplo:



$$I_{Csat} = \frac{V_{CC}}{R_C}$$

$$I_{Csat} = \frac{12}{2,2k}$$

$$I_{Csat} = 5,45mA$$



Circuito com polarização fixa

Exercício:

$I_B = ?$

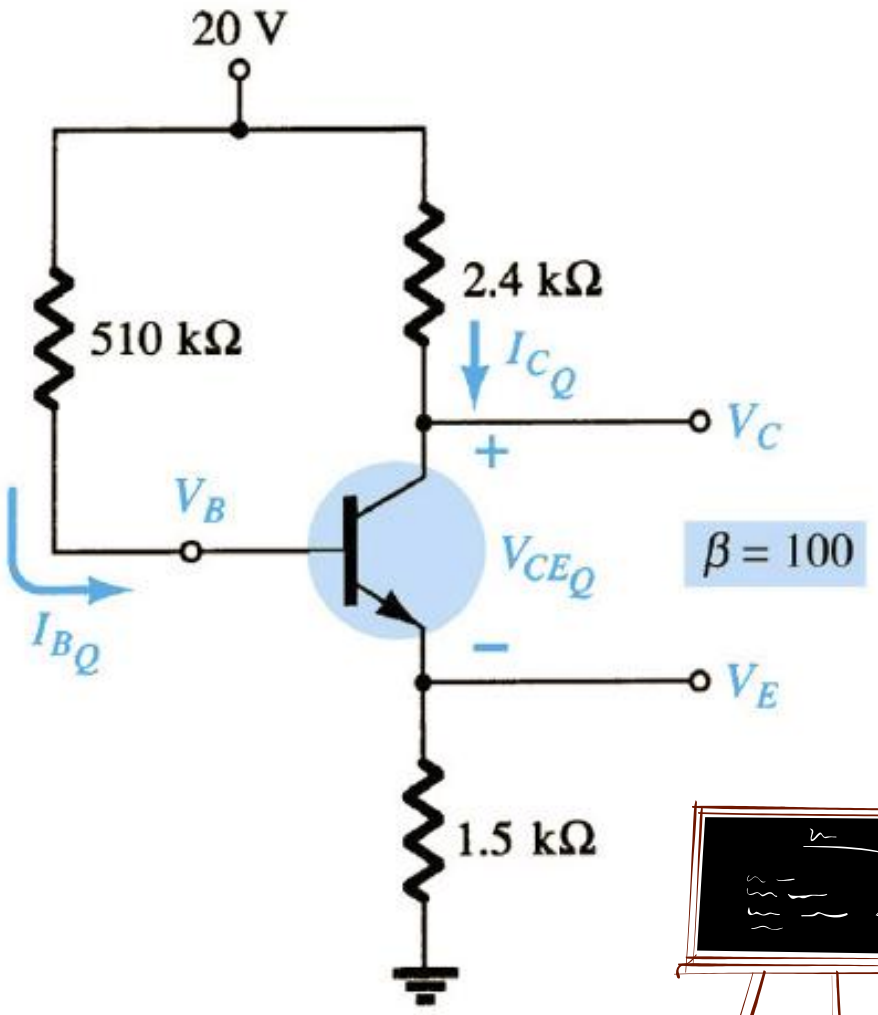
$I_C = ?$

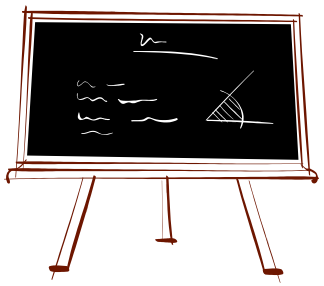
$V_{CE} = ?$

$V_C = ?$

$V_B = ?$

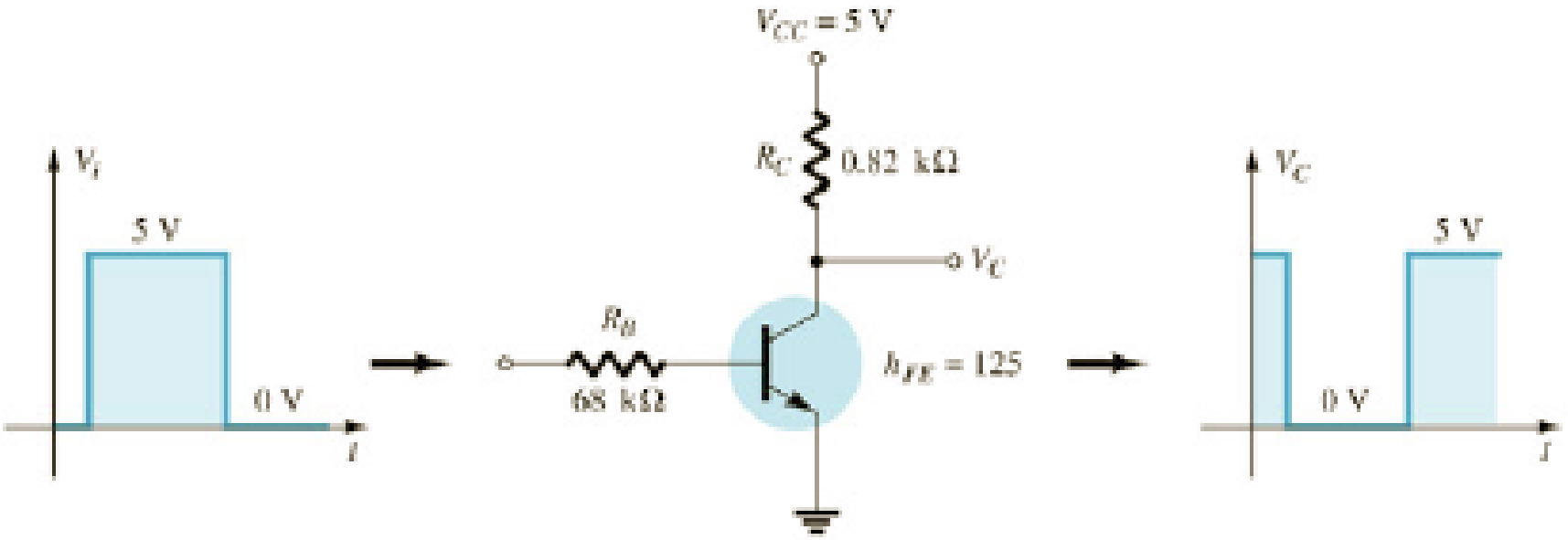
$V_E = ?$

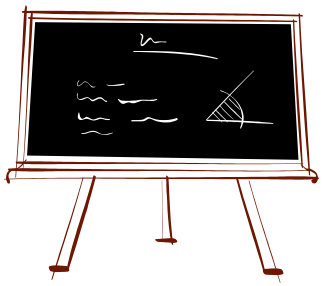




Aplicações dos BJTs

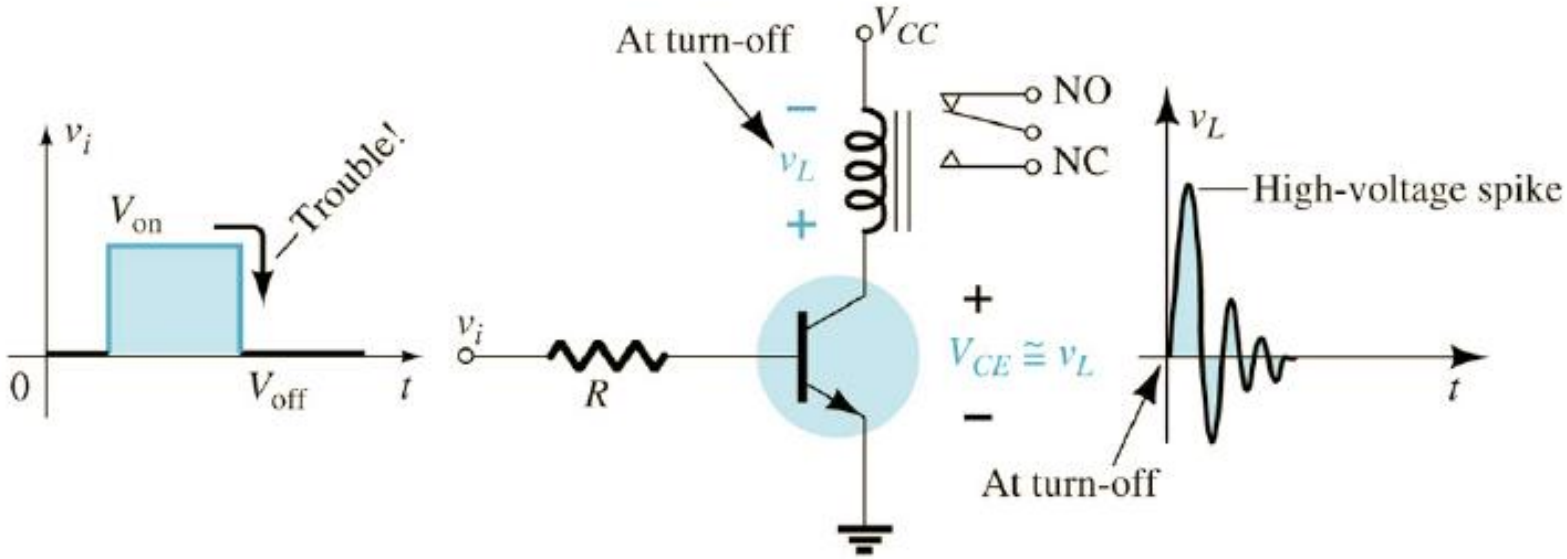
Porta lógica inversora:

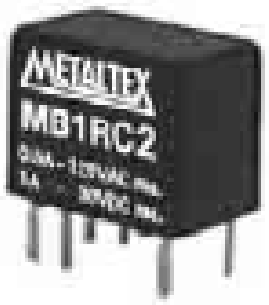


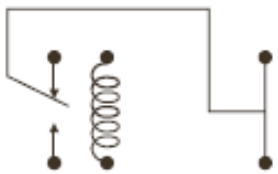


Aplicações dos BJTs

Acionando um relé:

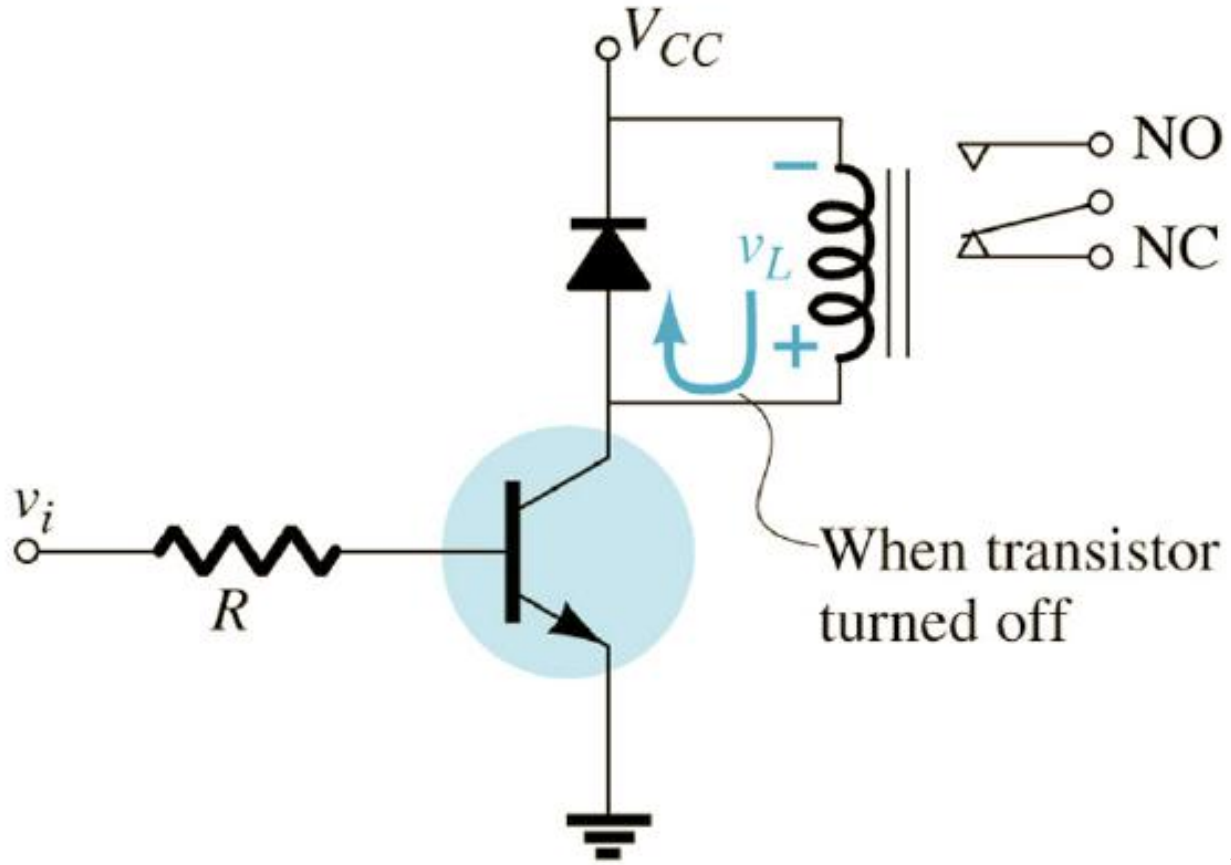


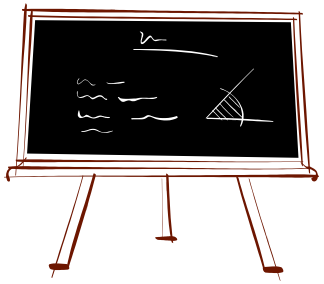




Aplicações dos BJTs

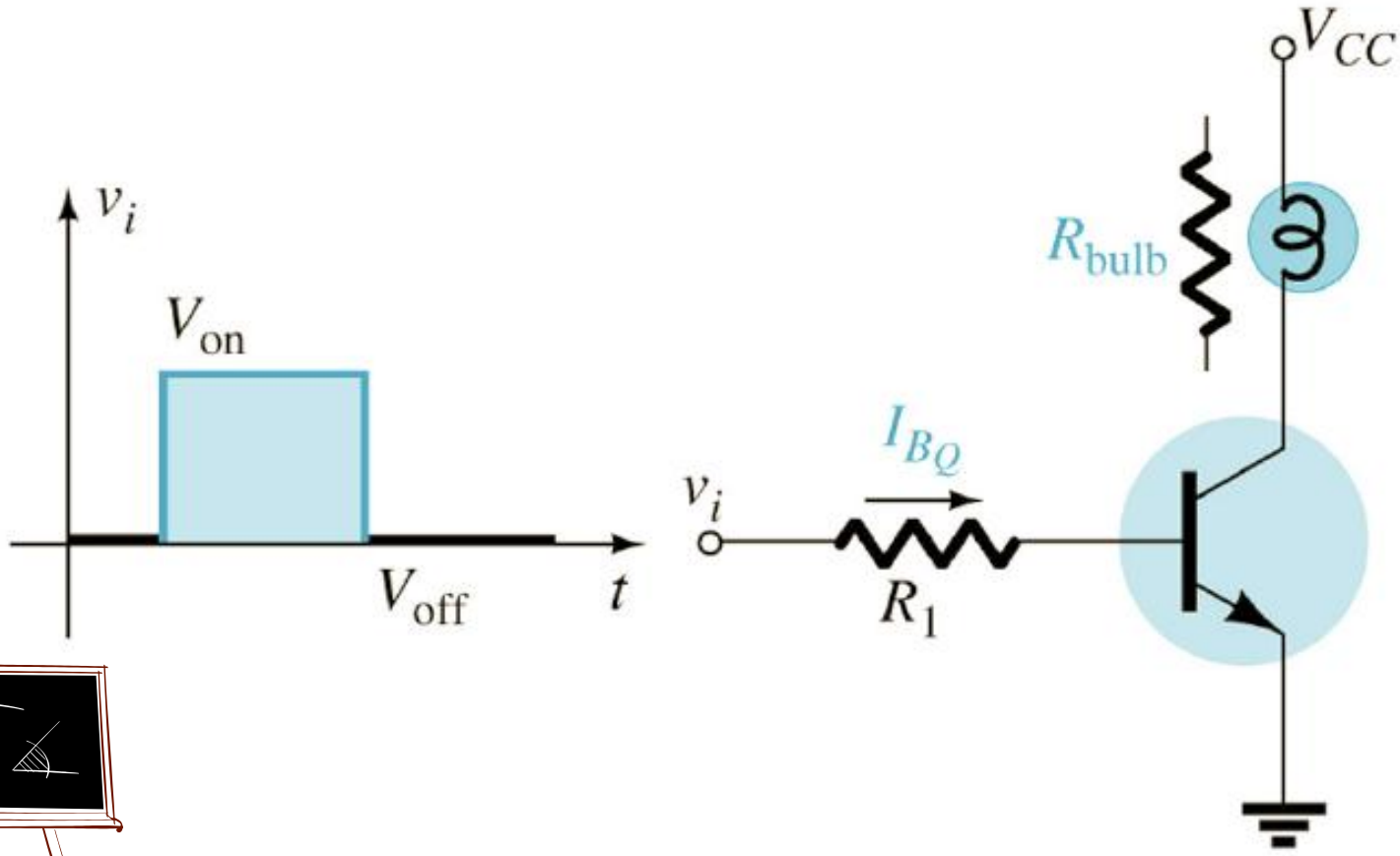
Acionando um relé:

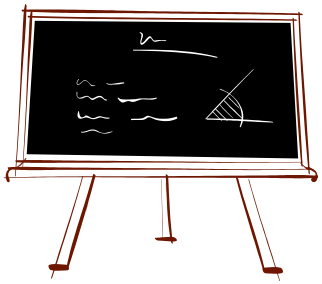




Aplicações dos BJTs

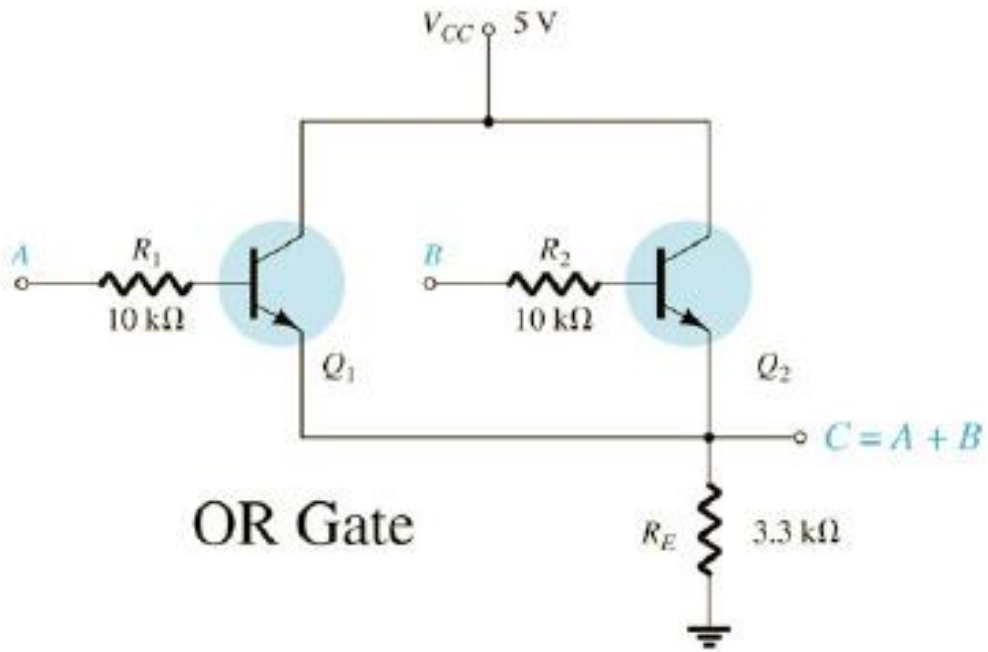
Chave a transistor:





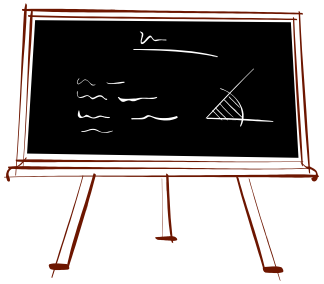
Aplicações dos BJTs

Porta lógica OU:



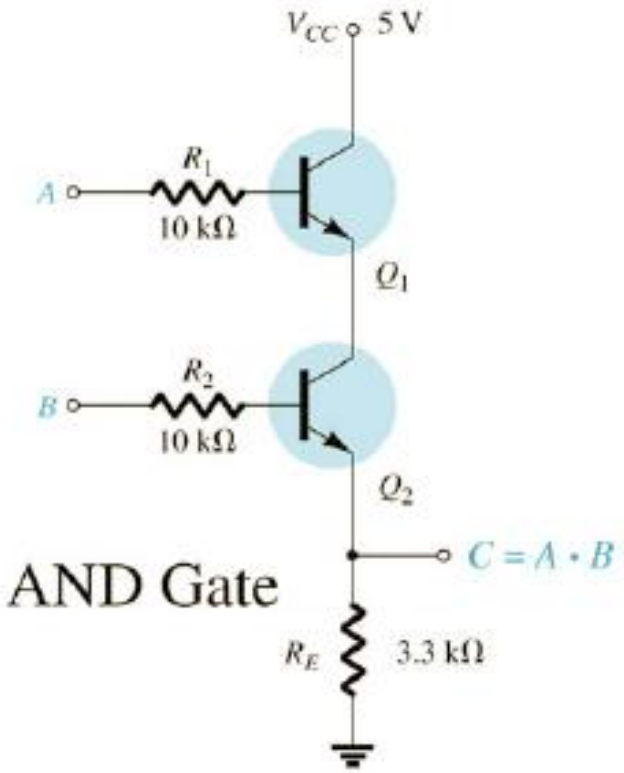
A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

1 = high
0 = low

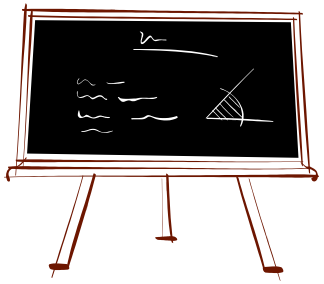


Aplicações dos BJTs

Porta lógica AND:

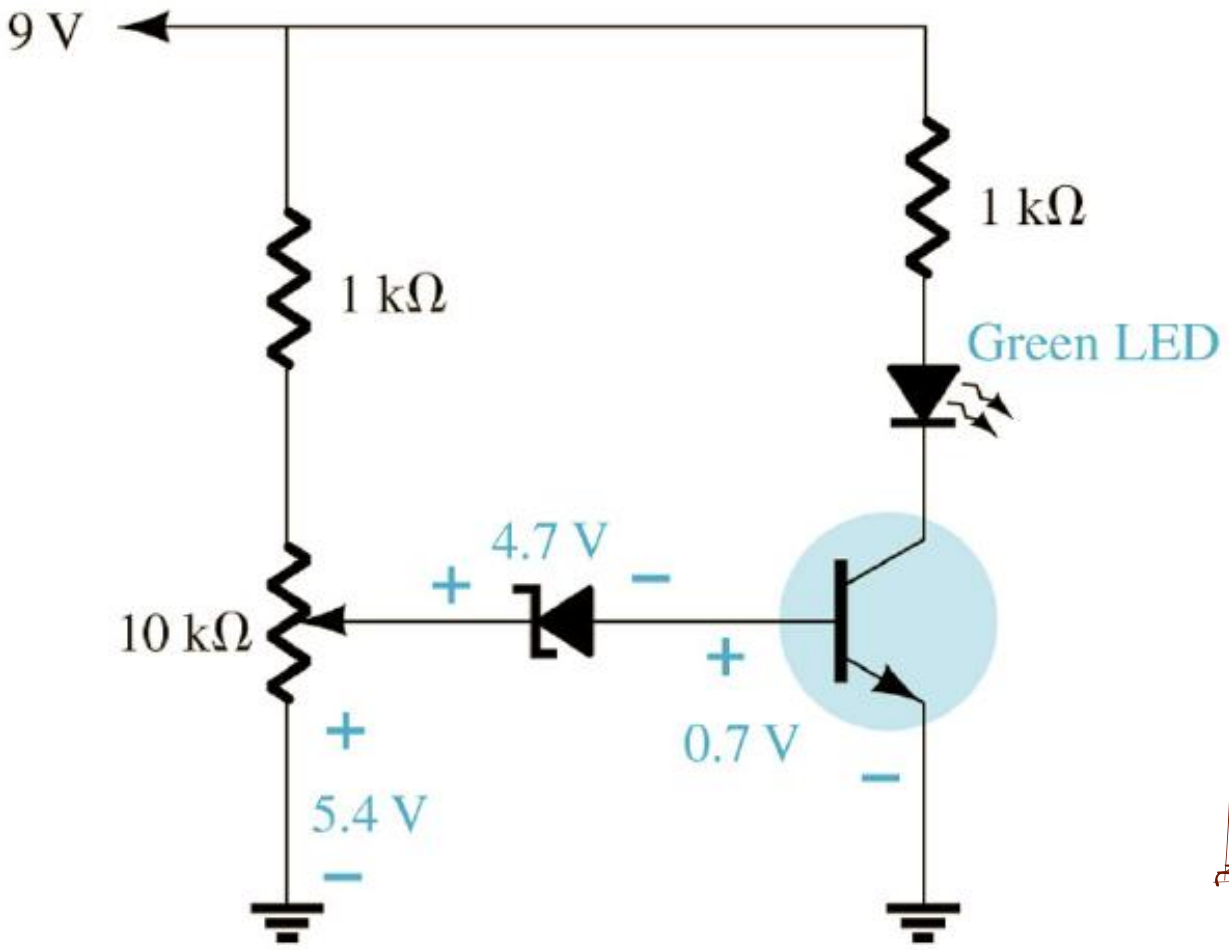


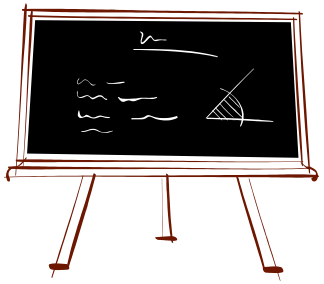
A	B	C
0	0	0
0	1	0
1	0	0
1	1	1



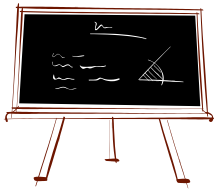
Aplicações dos BJTs

Indicador de nível de tensão:

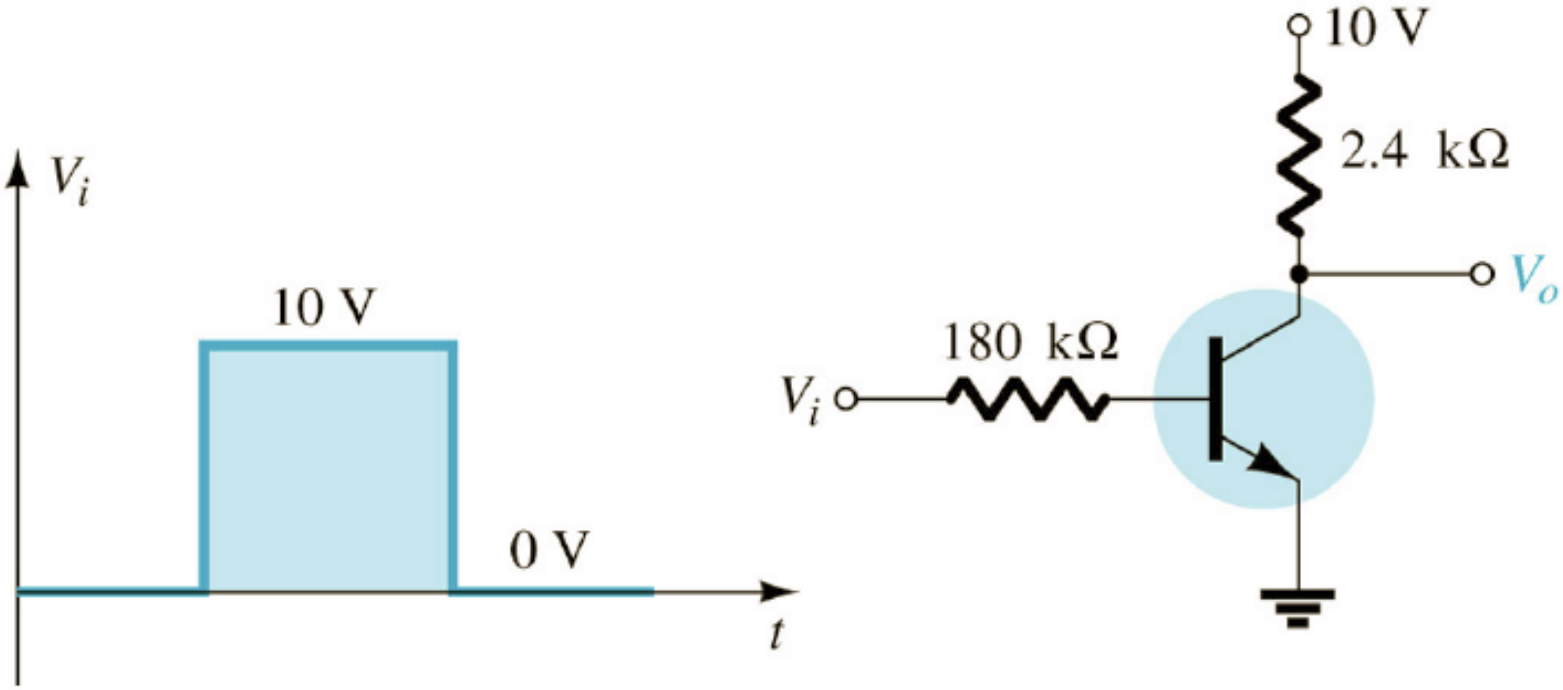




Aplicações dos BJTs

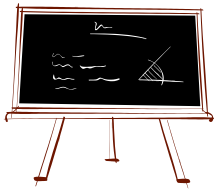


Exercícios:

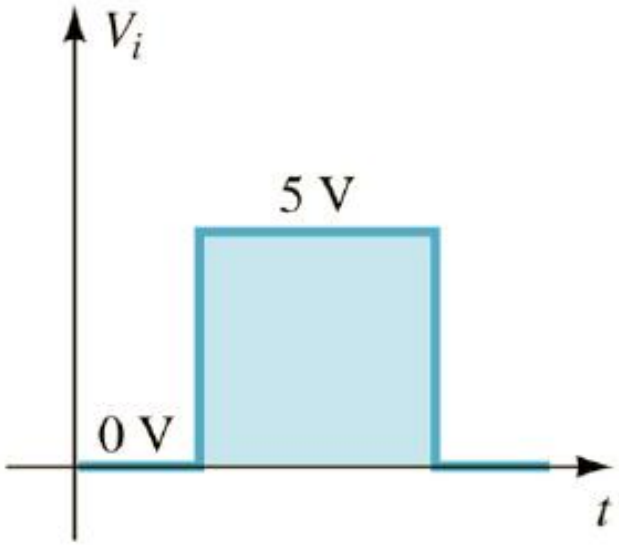


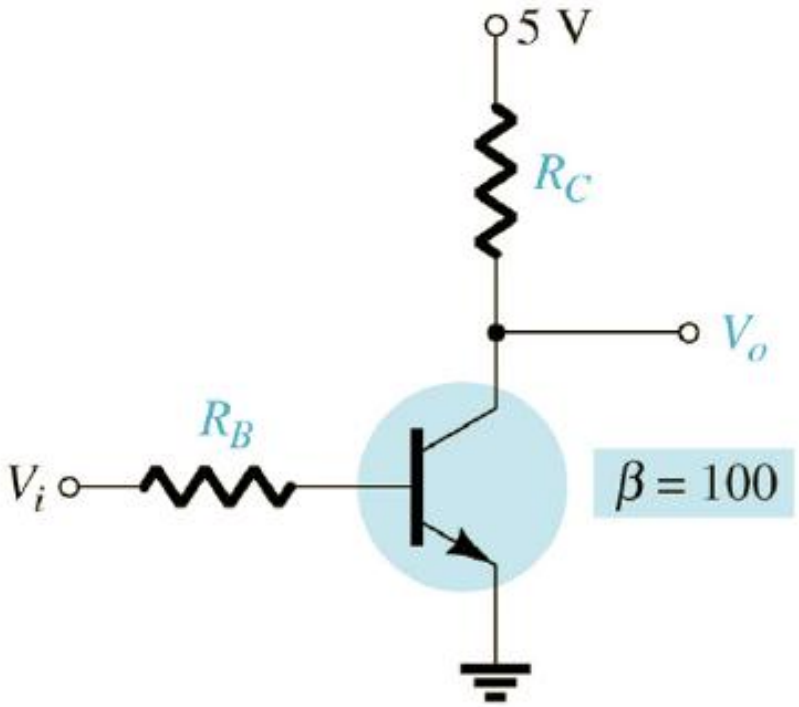
Verificar os estados de operação do transistor e desenhar a forma de onda de V_o.

Aplicações dos BJTs



Exercícios:





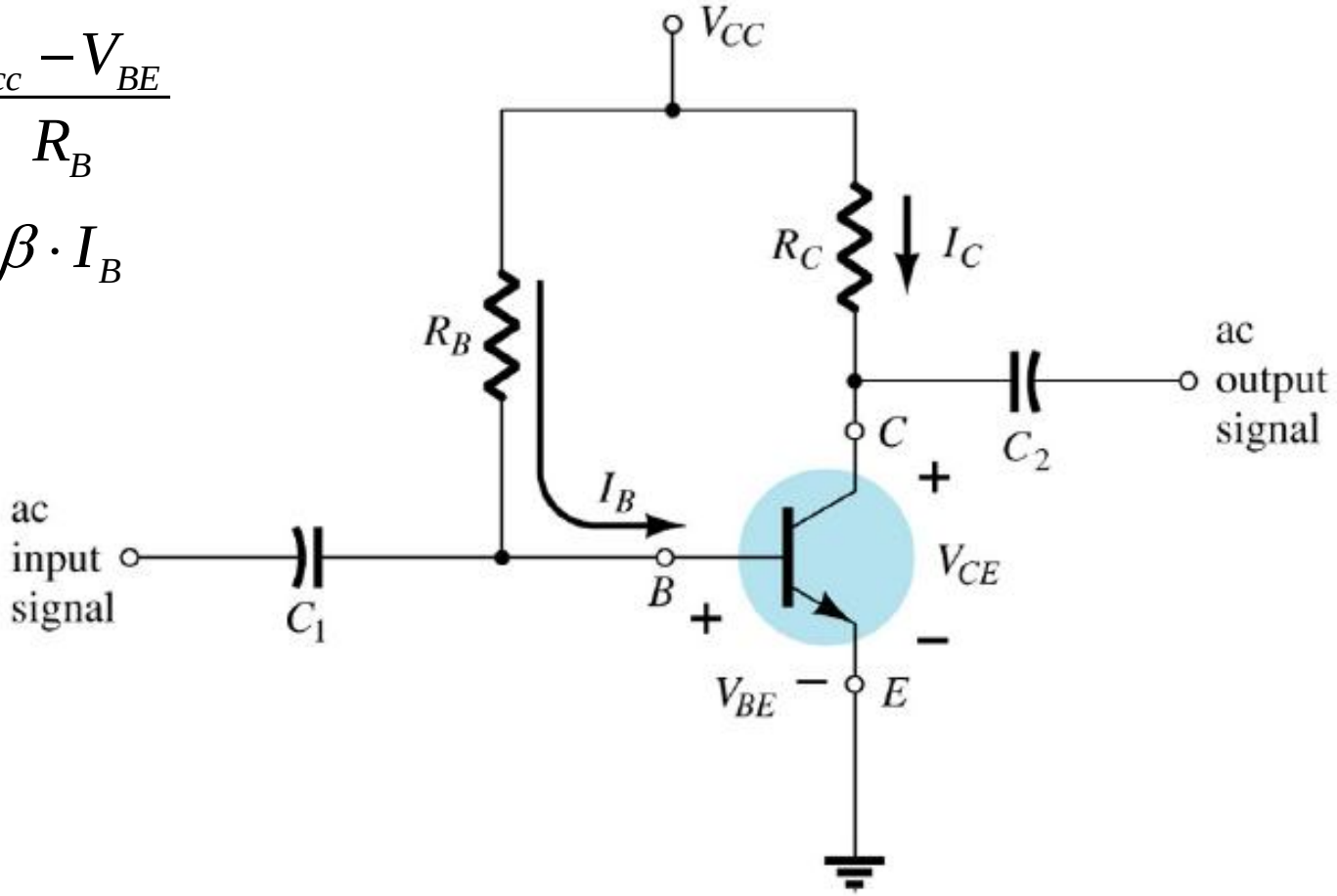
Determinar os resistores R_B e R_C para o circuito operar com porta lógica inversora.

Amplificador com polarização fixa

- **Dependente do ganho (β)**

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

$$I_C = \beta \cdot I_B$$



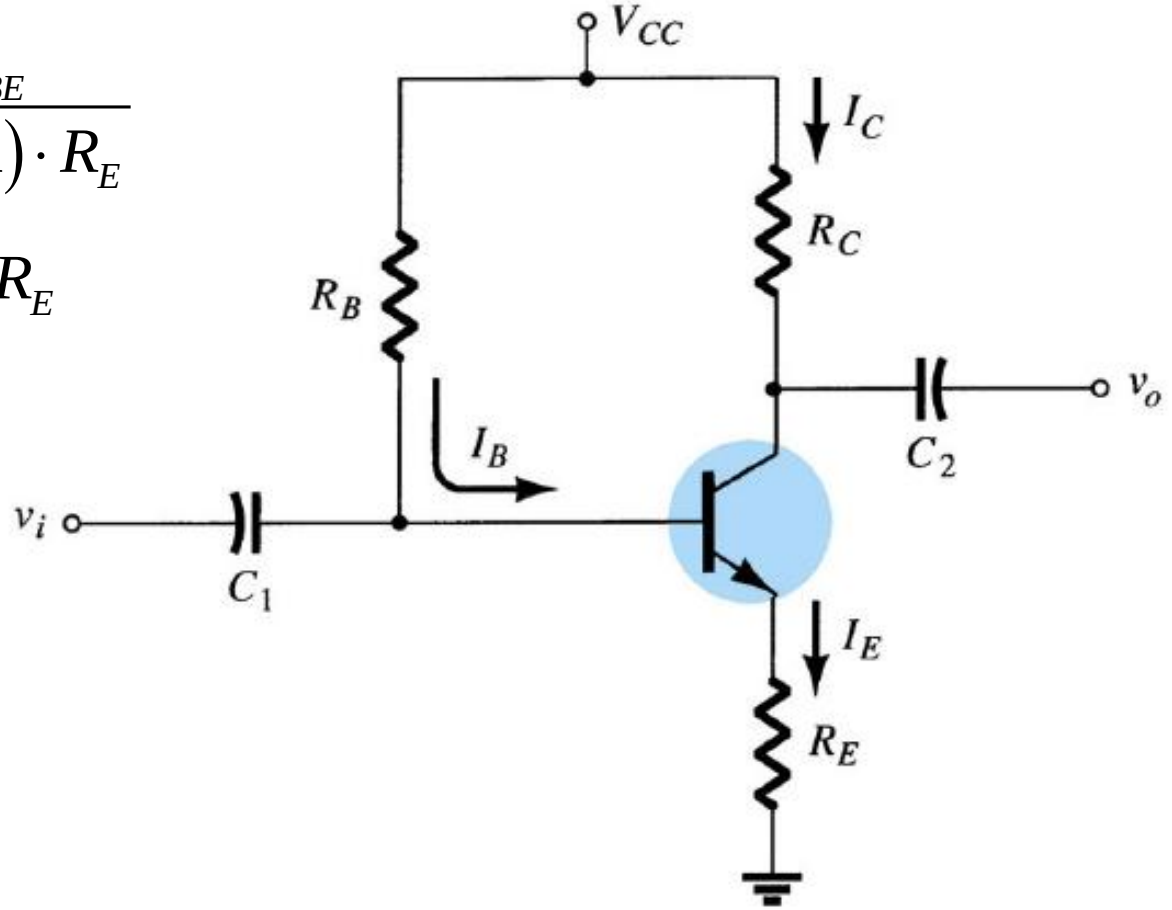
Amplificador com resistor de emissor

- **Melhora da estabilidade do emissor**

$$I_B = \frac{V_{cc} - V_{BE}}{R_B + (\beta + 1) \cdot R_E}$$

$$R_i = (\beta + 1) \cdot R_E$$

$$I_C = \beta \cdot I_B$$



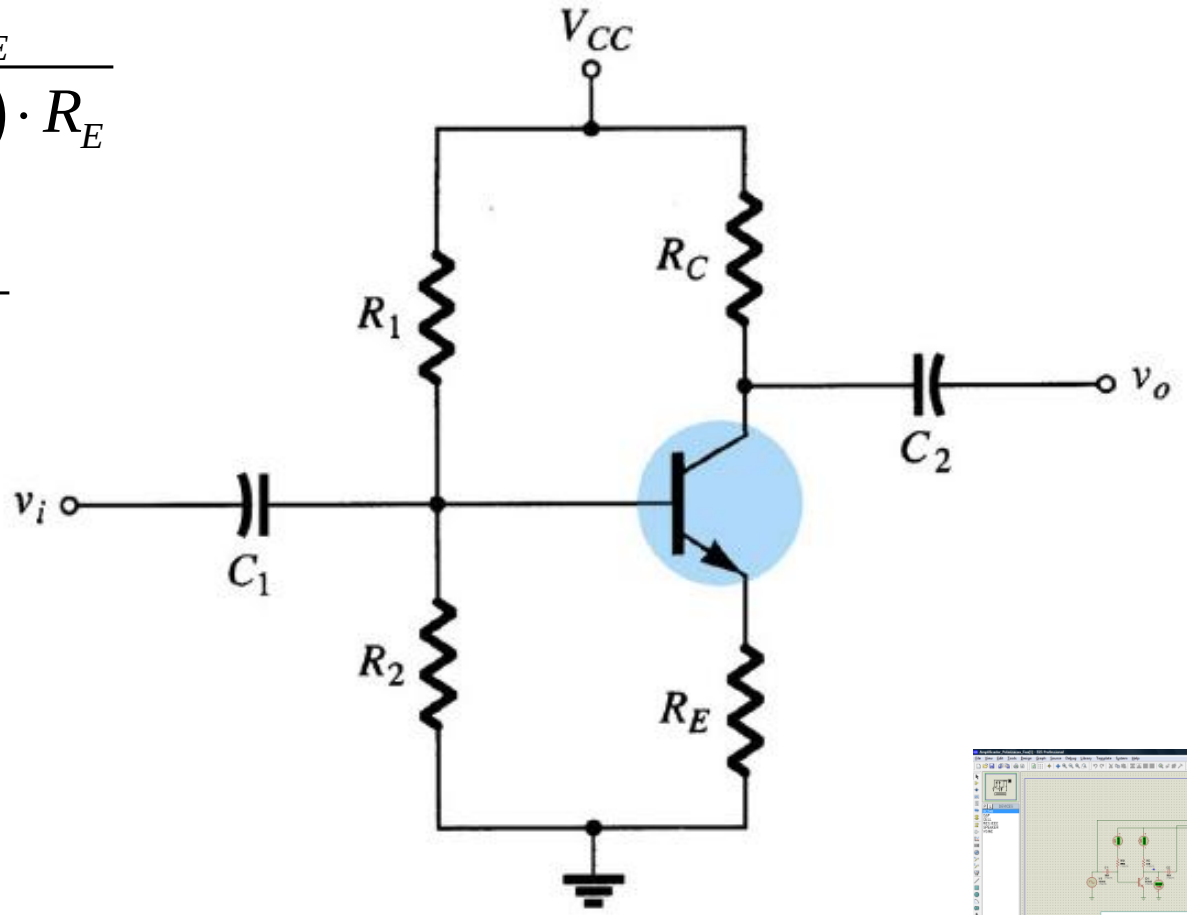
Amplificador polarização por divisor de tensão

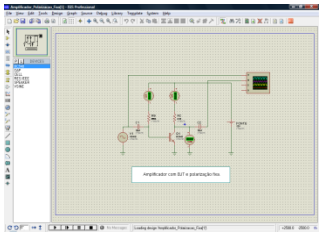
- **Independente do ganho (β)**

$$I_B = \frac{E_{TH} - V_{BE}}{R_{TH} + (\beta + 1) \cdot R_E}$$

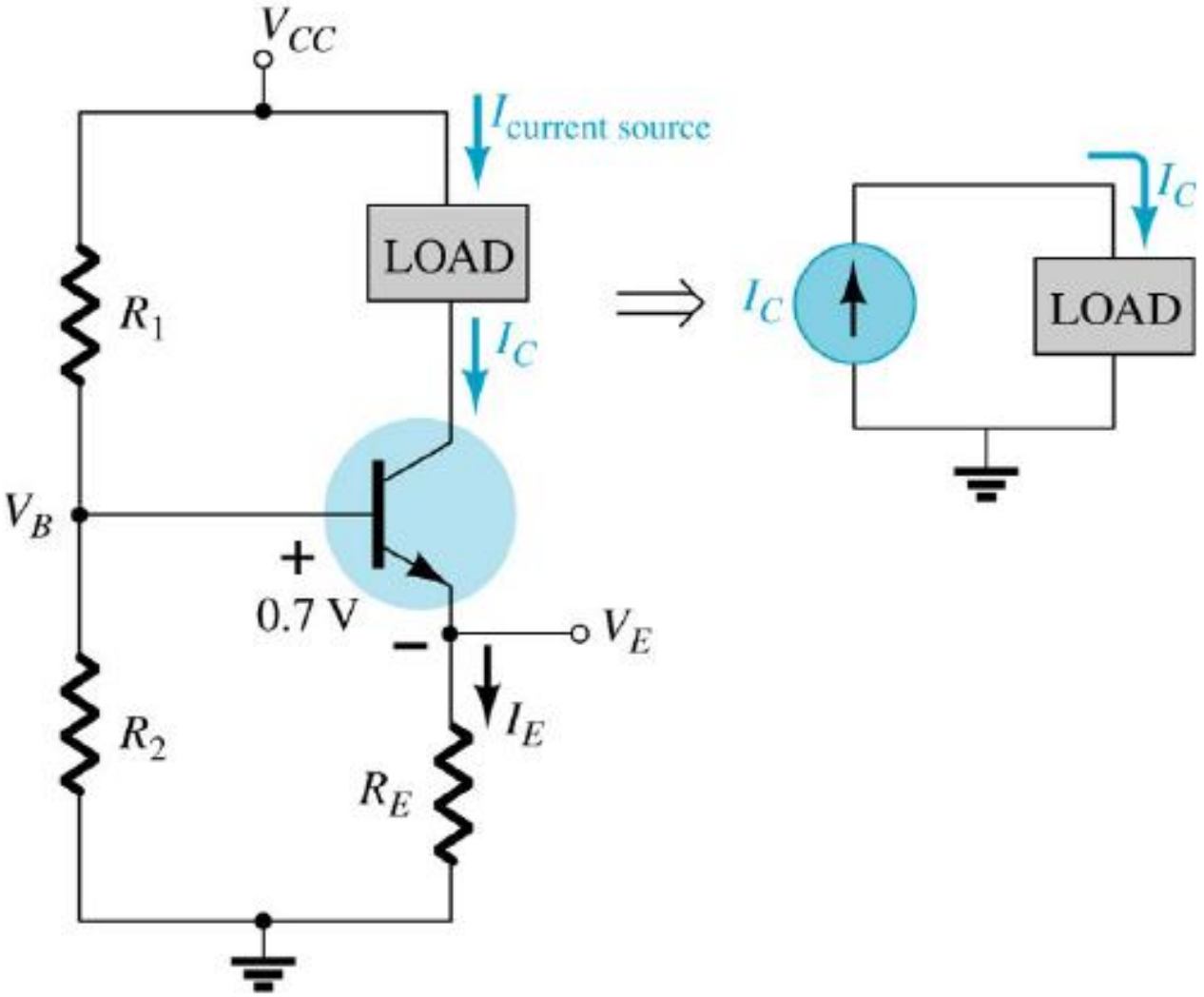
$$E_{TH} = \frac{R_2 \cdot V_{CC}}{R_1 + R_2}$$

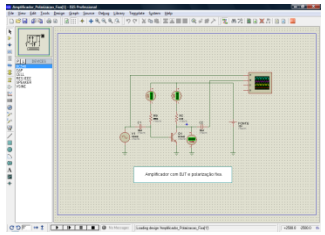
Tensão na base



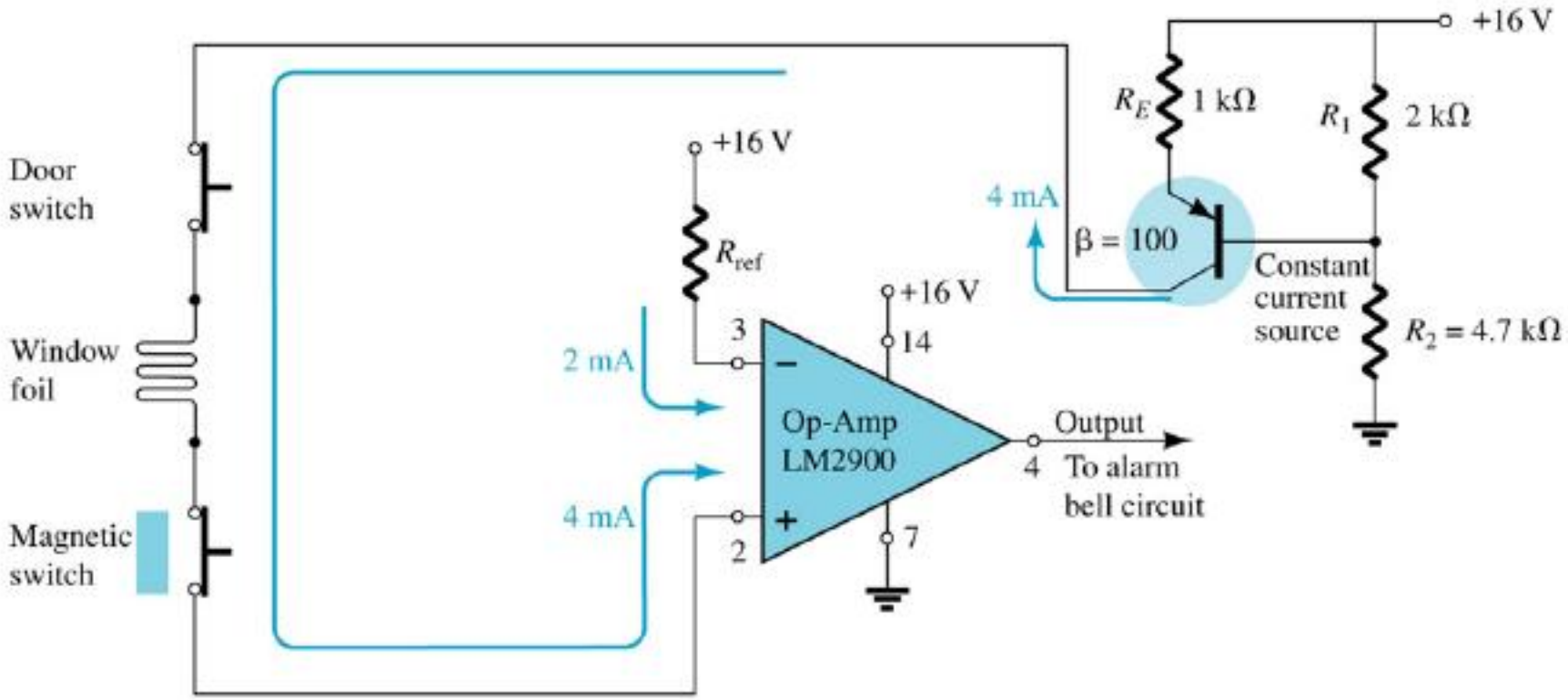


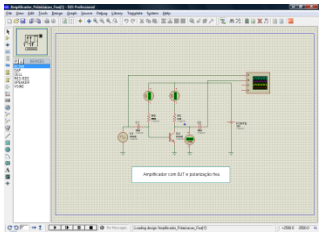
Fonte de corrente constante



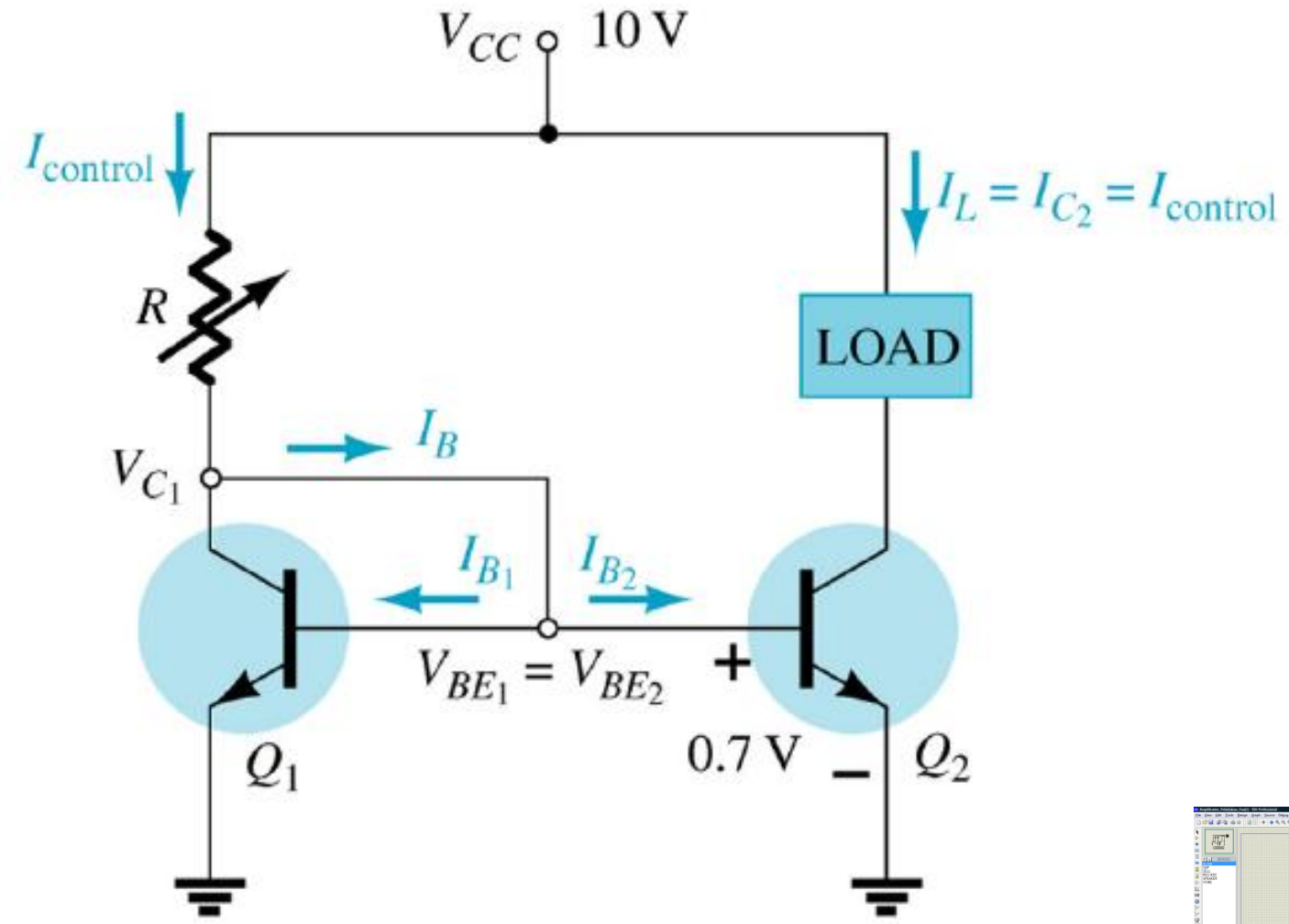


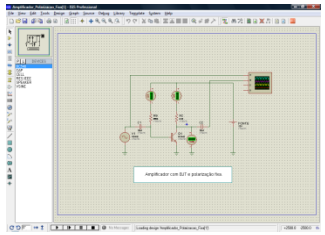
Sistema de alarme



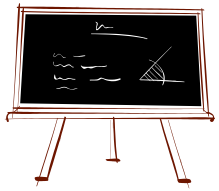


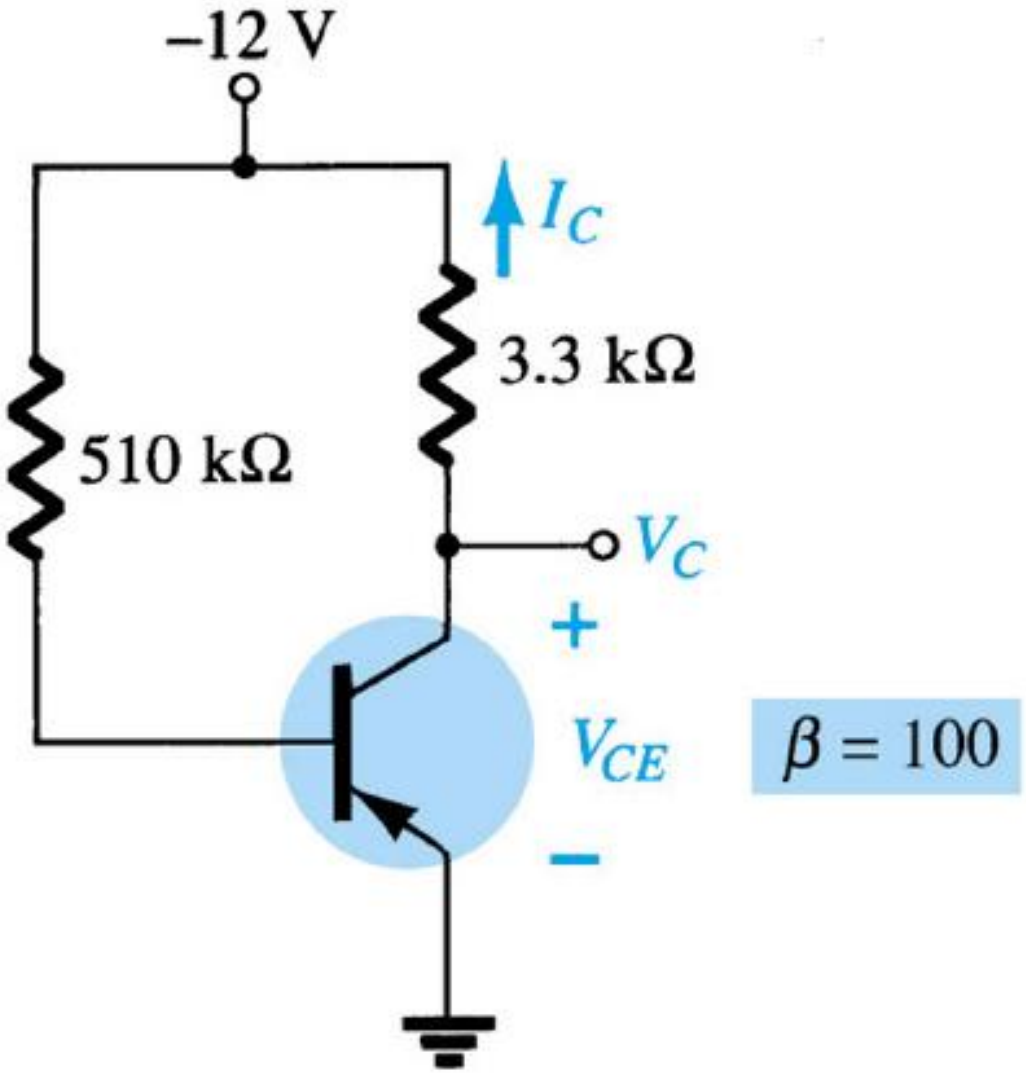
Espelho de corrente



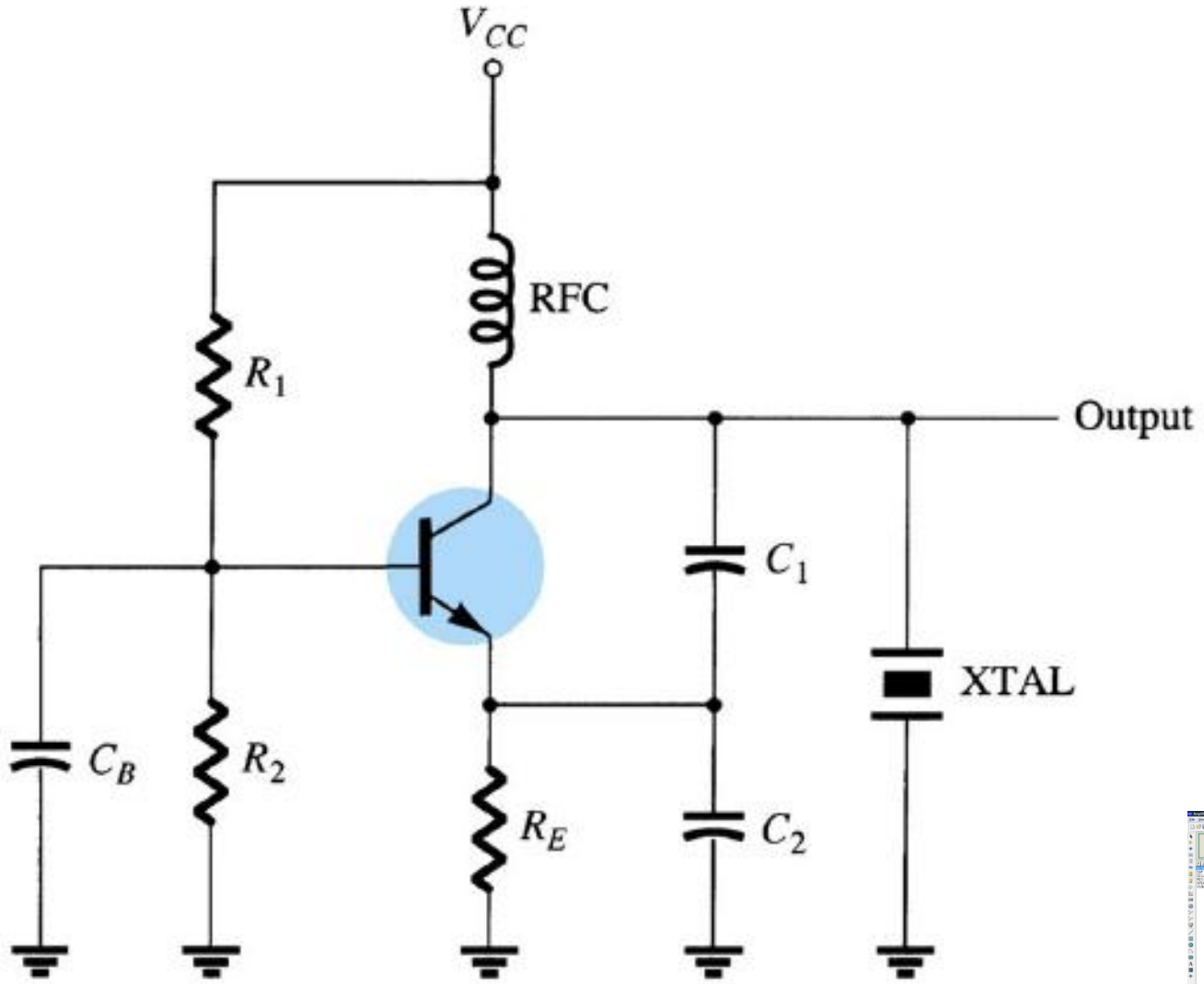


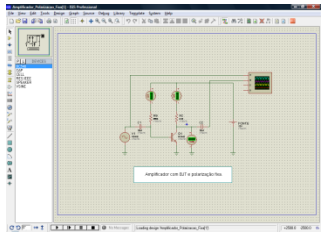
Polarização de transistor PNP



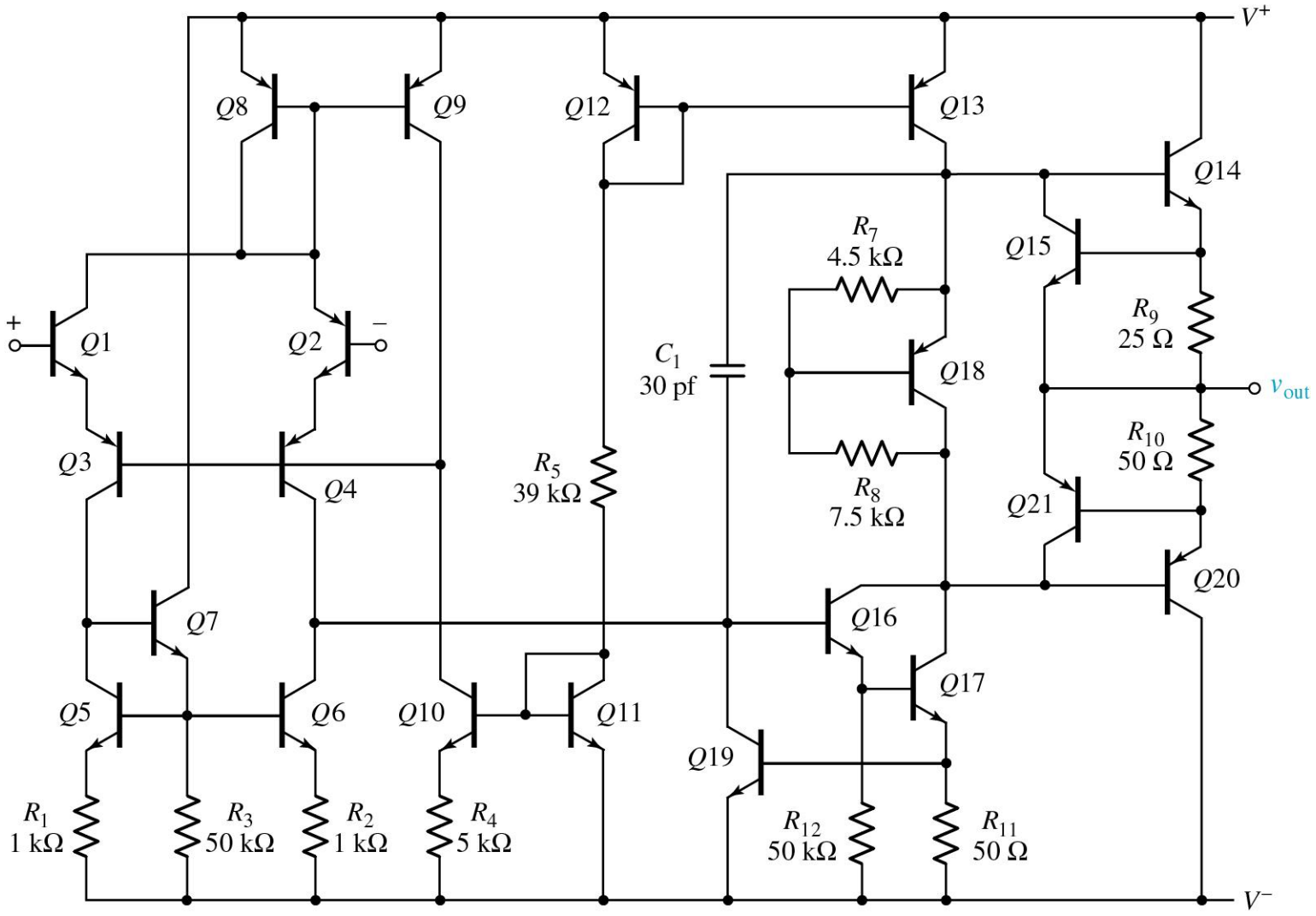


Oscilador controlado a cristal

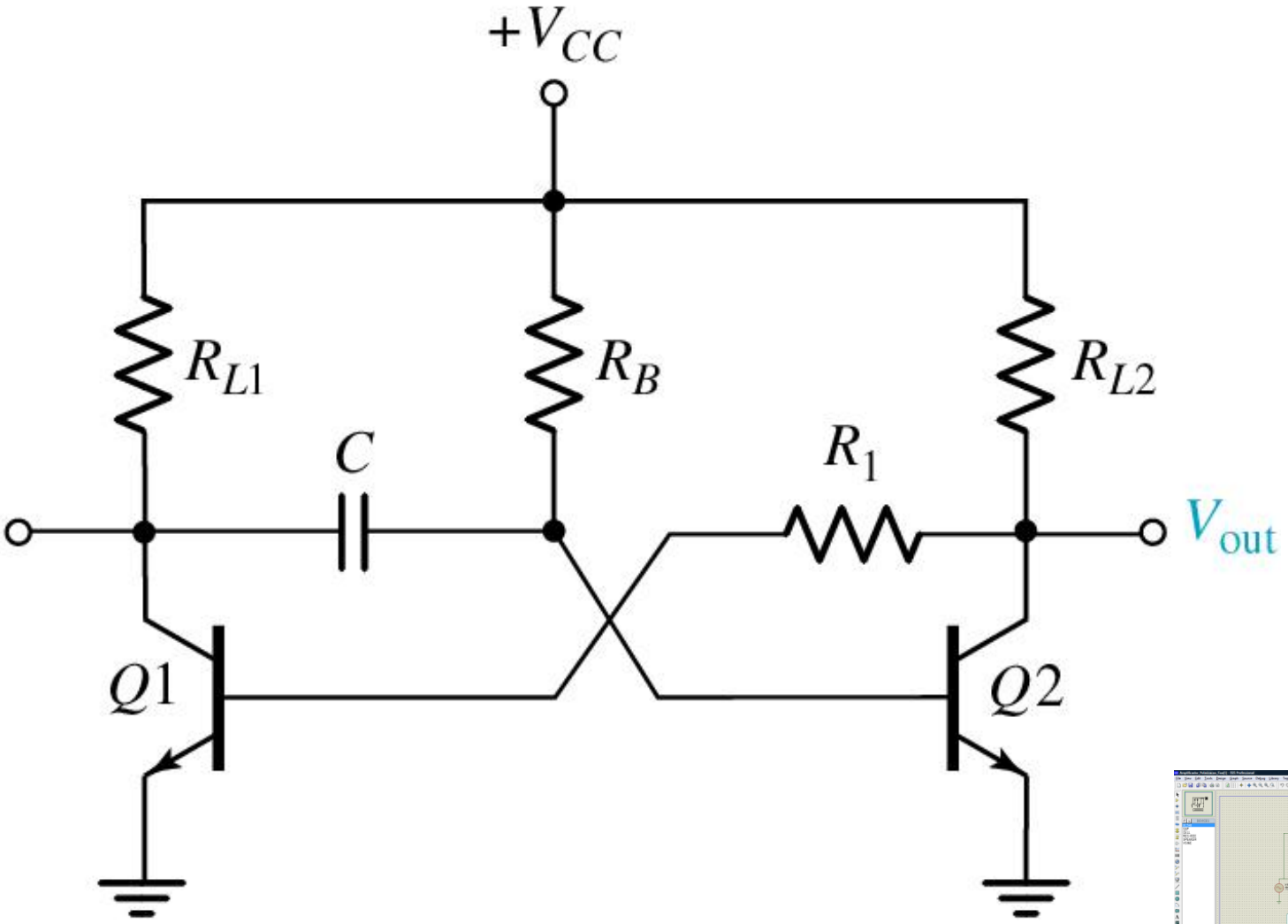


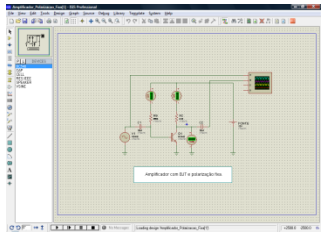


Amplificador operacional 741

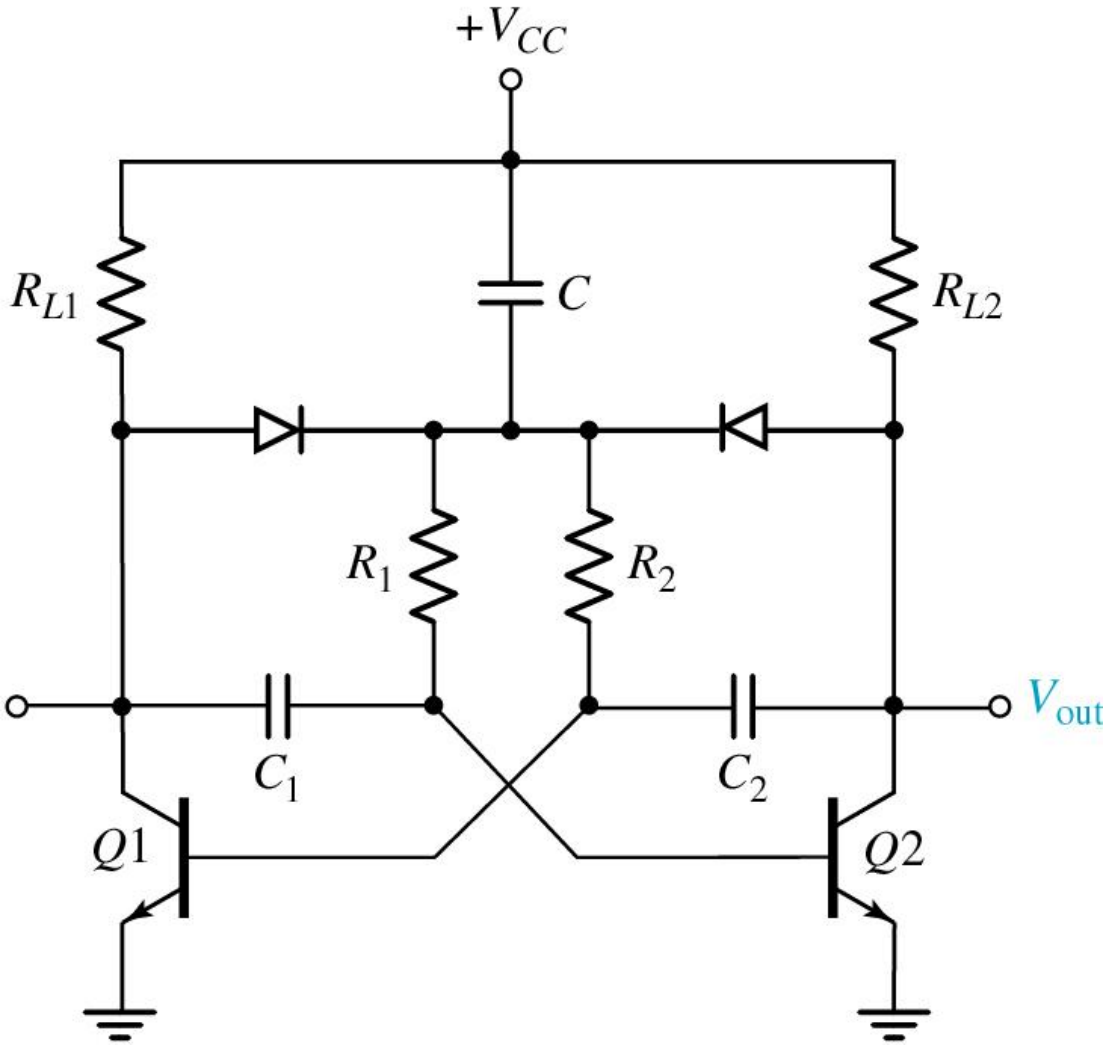


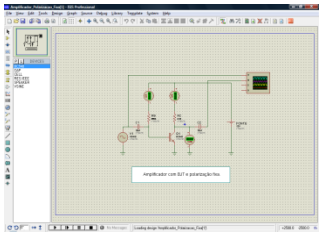
Multivibrador monoestável





Multivibrador astável





Próxima aula

Seqüência de conteúdos:

1. Laboratório:
   - Diodo zener;
   - Transistores;
   - Leds.