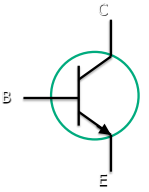
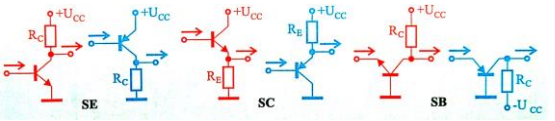
Electronics and Microelectronics
AE4B34EM

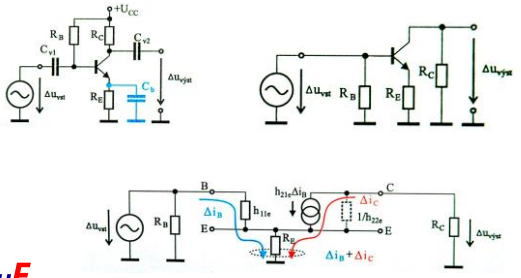
6. lecture
- Bipolar transistor
- Parameters
- Applications



Circuit variation



Amlifiers

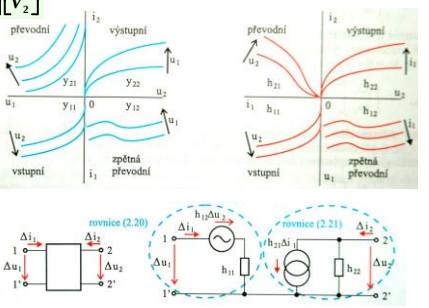


Linear model and *h* parameters

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

$$h_{11} = \frac{V_1}{I_1}\Big|_{V_2 = 0} \qquad h_{12} = \frac{V_1}{V_2}\Big|_{I_1 = 0}$$

$$h_{21} = \frac{I_2}{I_1}\Big|_{V_2 = 0} \qquad h_{22} = \frac{I_2}{V_2}\Big|_{I_1 = 0}$$



h - Parameters

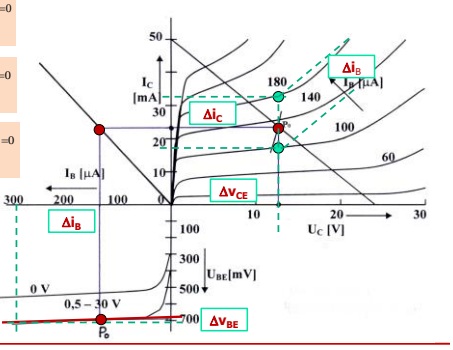
$$h_{11} = \frac{V_1}{I_1}\Big|_{V_2 = 0} \qquad h_{12} = \frac{V_1}{V_2}\Big|_{I_1 = 0}$$

$$h_{21} = \frac{I_2}{I_1}\Big|_{V_2 = 0} \qquad h_{22} = \frac{I_2}{V_2}\Big|_{I_1 = 0}$$

$h_{11} = h_i$ = Input Resistance
$h_{12} = h_r$ = Reverse Transfer Voltage Ratio
$h_{21} = h_f$ = Forward Transfer Current Ratio
$h_{22} = h_o$ = Output Admittance

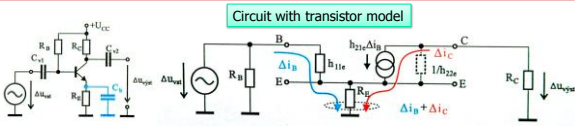
How to get h parameters from transistor characteristic

$$h_{1e} = \frac{\Delta v_{BE}}{\Delta i_B}\Big|_{\Delta u_{CE}=0} \qquad h_{2e} = \frac{\Delta i_C}{\Delta i_B}\Big|_{\Delta u_{CE}=0} \qquad h_{22e} = \frac{\Delta i_C}{\Delta v_{CE}}\Big|_{\Delta i_B=0}$$



BJT Amplifiers

Circuit with transistor model



- 1. Solution without capacitance C_B
- For simplicity, we neglect h_{21e} and h_{22e}

$$\Delta u_{výst} = -h_{21e}.\Delta i_B R_C$$

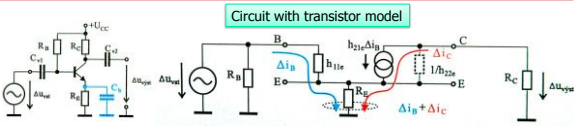
$$\Delta u_{vst} = h_{11e}.\Delta i_B + R_E.(\Delta i_B + h_{21e}.\Delta i_B) = [h_{11e} + R_E.(1+h_{21e})]\Delta i_B$$

- Voltage gain:

$$A_u = \frac{\Delta v_{výst}}{\Delta v_{vst}} = -\frac{h_{21e}.R_C}{h_{11e} + R_E.(1+h_{21e})}$$

BJT Amplifiers

Circuit with transistor model



- For $h_{11e} << R_E.(1+h_{21e})$

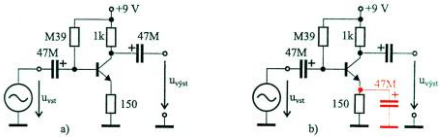
$$A_u = \frac{\Delta v_{výst}}{\Delta v_{vst}} = -\frac{R_C}{R_E}$$

- 2. With capacitance:

$$A_u = \frac{\Delta v_{výst}}{\Delta v_{vst}} = -\frac{h_{21e}.R_C}{h_{11e}}$$

BJT amplifier - example

- Calculate voltage gain. Given: h_{21e} 200 and h_{22e} 600 Ohm

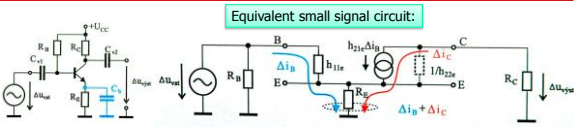


$$A_u = \frac{\Delta v_{výst}}{\Delta v_{vst}} = -\frac{R_C}{R_E} = \frac{1000}{150} = -6{,}67$$

$$A_u = \frac{\Delta v_{výst}}{\Delta v_{vst}} = -\frac{h_{21e}.R_C}{h_{11e}} = \frac{200.1000}{600} = -333$$

BJT amplifier– input and output resistance

Equivalent small signal circuit:



- Cb is included:

$$R_{vst} = R_B \| h_{11e}$$

- Cb is excluded :

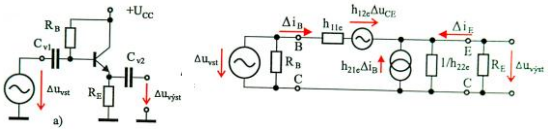
$$R_{vst} = R_B \| \left(\frac{\Delta v_{vst}}{\Delta i_B} \right)^{\Delta v_{výst}=0} = R_B \| [h_{11e} + R_E(1+h_{21e})]$$

- Output resistance:

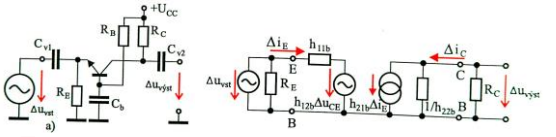
$$R_{výst} = (1/h_{22e}) \| R_C$$

Common collector and base circuits and equivalent small signal models

- Common collector circuit



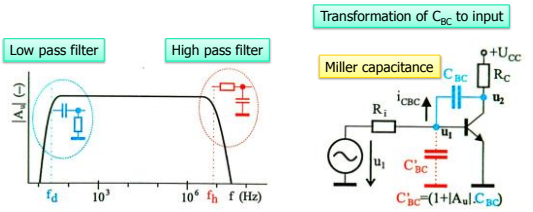
- Common base circuit



Properties of BJT amplifiers

Parametr	SE	SC	SB
A_u	$-(h_{21e}/h_{11e}).(R_C \| 1/h_{22e})$ velké	$(h_{21e}.R_E)/(h_{21e}.R_E+h_{11e})$ menší než 1	$(h_{21b}/h_{11b}).(R_C \| 1/h_{22b})$ velké
A_i	$h_{21e} >> 1$	$h_{21e} >> 1$	$[h_{21b}/(1+h_{22b}.R_C)] < 1$
$A_P = A_i.A_u$	velké	malé	malé
R_{vst}	$R_B \| h_{11e}$ střední	$R_B \| [h_{11e}+(h_{21e}+1).R_E]$ velký	$R_E \| h_{11b}$ malý
$R_{výst}$	$R_C \| (1/h_{22e})$ střední	$R_E \| [(h_{11e}+R_B)/h_{21e}]$ malý	$R_C \| (1/h_{22b})$ velký

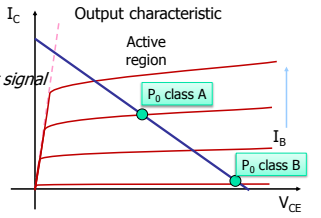
The lower and upper limit frequency

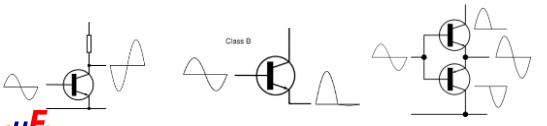


$C'_{BC}=(1+|A_u|.C_{BC})$

Amplifier class A and B

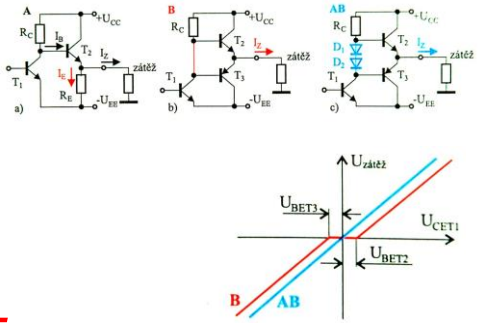
- Class A:
  - *Operating point in ½ Vcc*
  - *Linear*
  - *Consumes power without signal*
- Class B:
  - *Operating point is set*
  - *Nonlinear*
  - *No power without signal*





Amplifier class A and B

- s



BJT as a switch

- Switch with ohmic load