

3/4 (2. Halbttag) | Transistor und Transistorverstärker

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1 Introduction

In this experiment, the bipolar transistor is used, but here as an emitter sequence for voltage amplification and as an impedance converter (buffer). Also, the negative feedback of alternating current and the behavior of different frequencies will be observed via a cascode circuit.

2 Theory

The whole theory of different kinds of transistors is still needed.

An emitter follower is an electronic component, with which a current can be amplified (factor γ), without any change in voltage (factor v).

$$v = \frac{dU_E}{dU_B} \approx 1 \quad \gamma = \frac{dI_E}{dI_B} \approx 100. \quad (2.1)$$

This is why sometimes an emitter follower is called an impedance changer.

The negative feedback factor k denotes, which fraction of the output voltage is used for the negative feedback

$$\frac{1}{v} = \frac{1}{v_0} + k. \quad (2.2)$$

Though the amplification with negative feedback v is lower than the open-loop gain v_0 , v is only dependent on the circuit and not on the transistor itself. This amplification can be described as follows

$$\frac{dv}{v} = \frac{dv_0}{v_0} \frac{v}{v_0}. \quad (2.3)$$

The bandwidth of the amplifier circuit is the frequency band, in which the amplification is constant. To increase the bandwidth, one can use a cascode circuit. To achieve such an amplification, the alternating voltage feedback of the collector on the basis is reduced by utilizing a second transistor to prevent a voltage swing. Given an input signal, the resulting change in voltage will be significantly lower than the change in the output signal. This results in a higher bandwidth.

Stabilization of the operating point can be achieved by using negative feedback, in particular negative feedback of voltage.

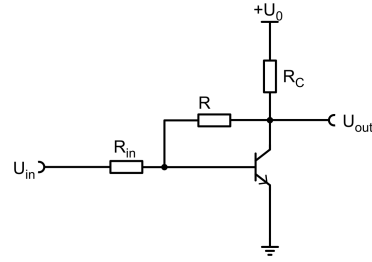


Figure 1: Transistor amplifier as common collector with negative feedback (voltage); figure 3/4.16 [1]

In this figure the resistor R sets the base potential as well as the operating point and couples the voltage from the collector back to the base. Due to this negative feedback the base current is reduced although the input current remains constant.

3 Preliminary Tasks

3.1 G

$$\text{ZL } v = \frac{\gamma R_E}{r_{BE} + \gamma R_E} \text{ with } \gamma = \frac{dI_E}{dI_B} \text{ and } r_{BE} = \frac{dU_{BE}}{dI_B}.$$

$$\begin{aligned} v &= \frac{dU_E}{dU_B} \\ \Leftrightarrow &= \frac{dI_E R_E}{dU_{BE} + dU_E} \\ \Leftrightarrow &= \frac{\frac{dI_E R_E}{dI_B}}{\frac{dU_{BE}}{dI_B} + \frac{dU_E}{dI_B}} \\ \Leftrightarrow &= \frac{\gamma R_E}{r_{BE} + \gamma R_E}. \end{aligned} \quad (3.1)$$

3.2 H

The equation applies

$$\begin{aligned} \frac{r_{\text{out}}}{r_{\text{in}}} &= \frac{\frac{dU_E}{dI_E}}{\frac{dU_B}{dI_B}} \\ \Leftrightarrow &= \frac{dU_E}{dI_E} \frac{dI_B}{dU_B} \\ \Leftrightarrow &= \frac{dU_E}{dU_B} \frac{dI_B}{dI_E} \\ \Leftrightarrow &\approx 1 \cdot \frac{1}{\gamma}. \end{aligned} \quad (3.2)$$

3.3 I

The equation applies

$$\begin{aligned} v &= \frac{dU_C}{dU_B} \\ \Leftrightarrow &= \frac{dI_C R_C}{dU_{BE} + dU_E} \\ \Leftrightarrow &= \frac{\frac{dI_C R_C}{dI_B}}{\frac{dU_{BE}}{dI_B} + \frac{dU_E}{dI_B}} \\ \Leftrightarrow &= \frac{\beta R_C}{r_{BE} + \gamma R_E}. \end{aligned} \quad (3.3)$$

3.4 J

The equation applies

$$\begin{aligned} \frac{1}{v} &= \frac{1 + kv_0}{v_0} \\ \Leftrightarrow v &= \frac{v_0}{1 + kv_0} \\ \Leftrightarrow \frac{dv}{dv_0} &= \frac{1}{(1 + kv_0)^2} \\ \Leftrightarrow &= \frac{v}{v_0} \frac{1}{1 + kv_0} \\ \Leftrightarrow \frac{dv}{v} &= \frac{dv_0}{v_0} \frac{1}{1 + kv_0} \\ \Leftrightarrow &= \frac{dv_0}{v_0} \frac{v}{v_0}. \end{aligned} \quad (3.4)$$

3.5 K

The parallel capacitor with capacitance C_{CB} and transistor form a high-pass filter. This means that high frequency signals will run through the capacitor and not the transistor, resulting in them not being amplified.

3.6 L

$$(3.3) \quad \text{There is no voltage change at point P, because the input signal to the transistor T2 is constant. The change in current } dI_E(T_2) \text{ is in return also zero.}$$

3.7 M

For any transit frequency the equation holds $f_{\text{grenz gk}}(f=0) = f_{\text{grenz}} v_0$. Thus $f_{\text{grenz gk}} = f_{\text{grenz}} \frac{v_0}{v(f=0)}$.

3.8 N

For increasing base current I_B , the collector voltage U_C and the voltage across the resistor U_{RC} also increases. Because U_0 should be constant, the voltage drops across the resistor R , which in turn stabilizes the operating point.

4 Analysis

4.1 Voltageamplifier of the common collector

On Circuit Board 1 (Fig. 2) we construct a common collector with $dU_B = 2.1 \text{ V}_{\text{PP}}$ and $U_B \approx 2 \text{ V}$. To test the voltage amplification we chose a variety of different resistor combinations. The measurements are displayed in Tab. 1. We expect no change for different R_E .

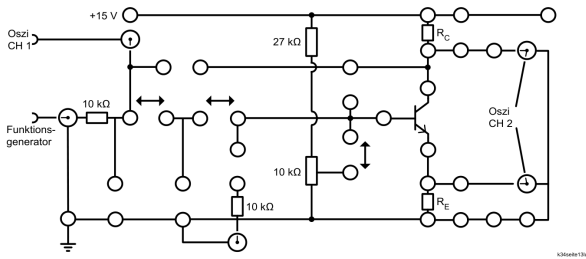


Figure 2: Circuit Board 1[1]

R_C	R_E	amplification ν
360 Ω	1 k Ω	1.000(25)
360 Ω	22 k Ω	1.025(25)
360 Ω	47 k Ω	1.015(25)
1 k Ω	360 Ω	0.945(25)
22 k Ω	360 Ω	0.114(25)
47 k Ω	360 Ω	0.120(25)

Table 1: Voltage amplification for different resistor combinations

As we see, there is no significant variation of the amplification for different R_E . Though we can clearly see a lowering of the amplification for higher R_C , which is plausible since we have less current that can be amplified.

4.2 Common Collector as Buffer Amplifier

Here we are tasked to match the impedance of a speaker, so we are able to hear a output. For this we firstly construct a Inverted Amplifier and test the speaker solely without a Common Collector. We observe, that the speaker does not produce any sound, because we haven't matched the impedance. Now we add a Common Collector as a Buffer Amplifier, which in theory should be able to match the impedance of the speaker. Unfortunately we could not get the circuit running and test the hypothesis.

4.3 Inverted Amplifier

4.3.1 Phasereleation

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Source

- [1] Fabian Hügging. *Elektronik-Praktikum Versuchsanleitung*. Universität Bonn, kurs b edition, 2024.