# Lab 138 - Transistors and Amplifiers

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**Abstract**

"This lab is meant to teach and show the practical use of NPN bjt amplifiers. The lab includes constructing and measuring DC circuits, calculating biasing networks, amplification, bandwidth and plotting characteristic curves of circuit parameters."

## Contents

# 1 Ic-Uce-characteristics

## 1.1 Circuit

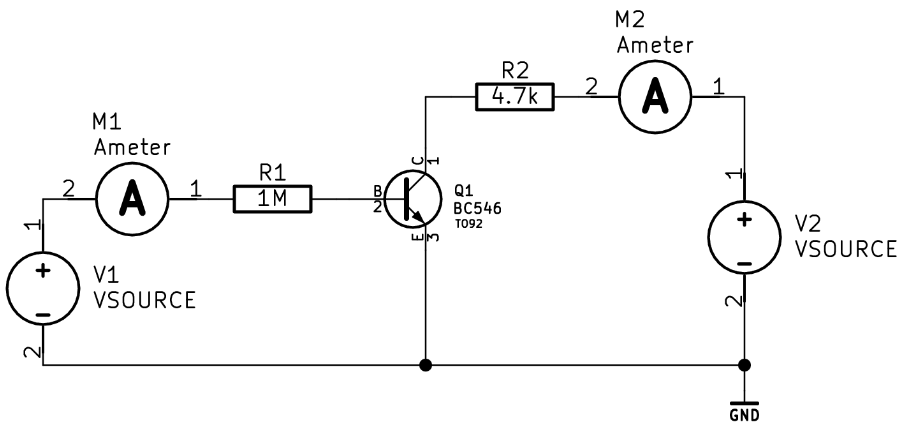


Figure 1: Measurement setup

### 1.1.1 Fixed collector voltage

With the collector resistor R2 left out or shorted, an adjustable power supply is connected directly across the collector-emitter junction, fixing the collector voltage. First we get the base currents for known collector currents. Adjusting voltage V1 translates to varying the base current Ib and in turn the collector current Ic. The transistor used is a BC547C.

### 1.1.2 Measurements

| Ic (mA) | Ib (µA) |
|---|---|
| 0.5 | 1.14 |
| 1.0 | 2.11 |
| 1.8 | 3.72 |

Table 1: Measurement of base current vs collector current

The base current is then held at a constant value and the collector-emitter voltage is swept over a range of 0-10V in 1V steps. The results is given in the plot.

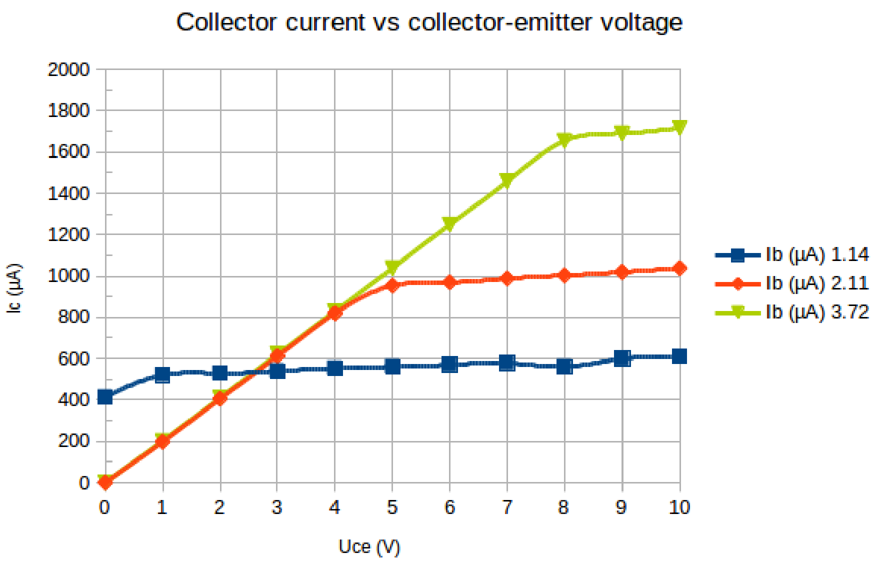


Figure 2: Ic-Uce results

#### 1.1.3 Simulation

Spice circuit simulation confirms that measurements reflect typical bjt characteristics. The program used is Linear Technology ltspice, models extracted from transistor datasheet parameters.

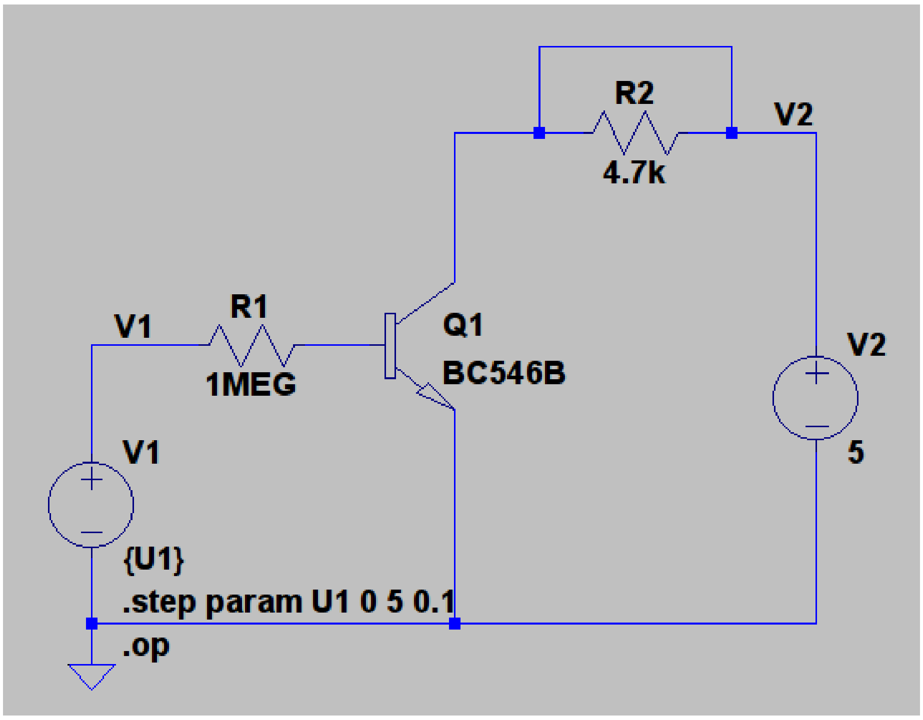


Figure 3: Ltspice schematic

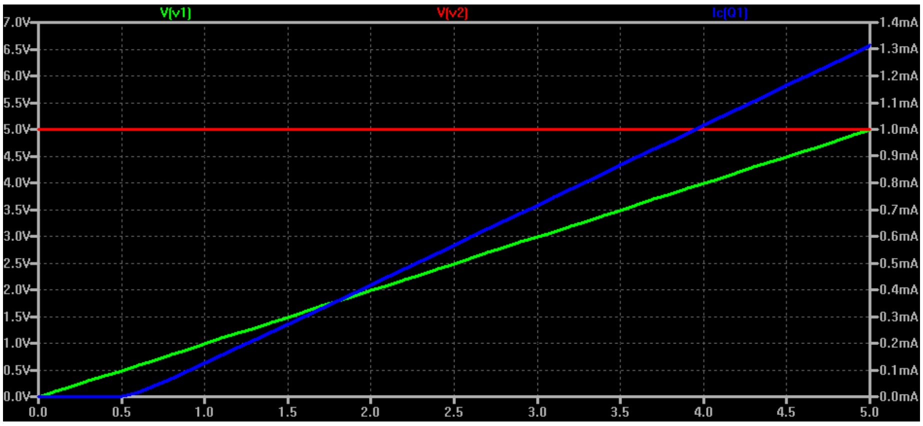


Figure 4: Ltspice simulation of Ic-Uce-characteristics

# 2 Quiescent conditions

## 2.1 Circuit

E = 10V Rc = 4.7kΩ


Figure 5: TODO

### 2.1.1 Curve

TODO

# 3 Uce/Ib transfer function

Examine the output signal of the first circuit. Determine the linearity of the output, as in the relation of Uce to Ib. Uses the measurement setup and circuit shown in Figure 1.

# 4 Ic/Ib characteristics and current amplification

## 4.1 Measurements

## 4.2 Comments

TODO: Comment the curve, calculate current amplificationfactor deltaIc/deltaIb in regions of interest.


Figure 6: TODO


Figure 7: Ic as a function of Ib

# 5 BJT biasing

| Rb | Ve | Ve | Rc |
|---|---|---|---|
| 390kΩ | 00 | 00 | 00 |
| 470kΩ | 00 | 00 | 00 |
| 560kΩ | 00 | 00 | 00 |
| 680kΩ | 00 | 00 | 00 |
| 820kΩ | 00 | 00 | 00 |
| 1MΩ | 00 | 00 | 00 |

Table 2: Bias resistor with bias voltages

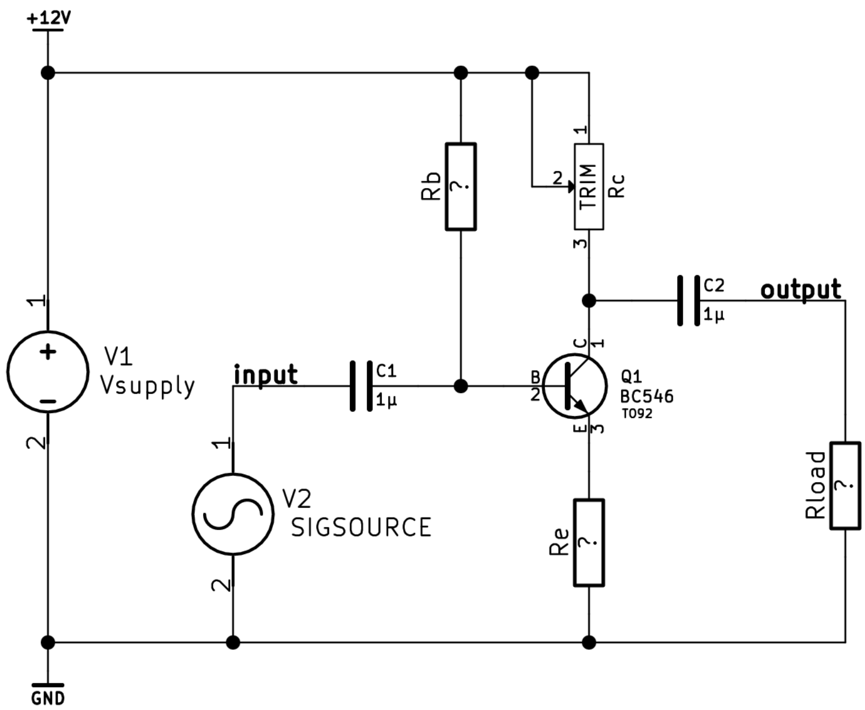


Figure 8: BJT biasing circuit

# 6 BJT amplifier

### 6.0.1 Amplification

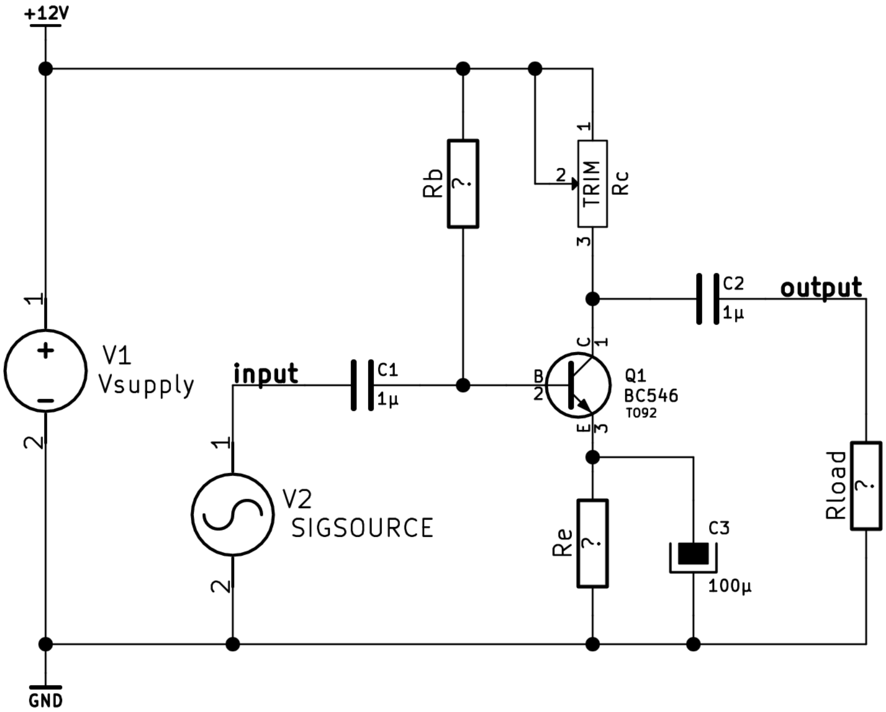


Figure 9: AC bypassed BJT amplifier

| | Without AC bypass | AC bypassed |
|---|---|---|
| Input voltage (mVtt) | 111 | 111 |
| Output voltage (Vtt) | 111 | 111 |
| Voltage gain (multiple) | 111 | 111 |
| Voltage gain (dB) | 111 | 111 |
| Phase shift (degrees) | 111 | 111 |

Table 3: Amplifier gain measurements

### 6.0.2 Frequency response

### 6.0.3 Improved biasing

The one resistor base bias is in practice not very reliable as it is dependant on transistor beta. A more practical design that scales better for production adds a second resistor, forming a voltage divider that fixes the base at a suitable level. For maximum dynamic range half of Vsupply, plus a diode drop to compensate for the base-emitter voltage.

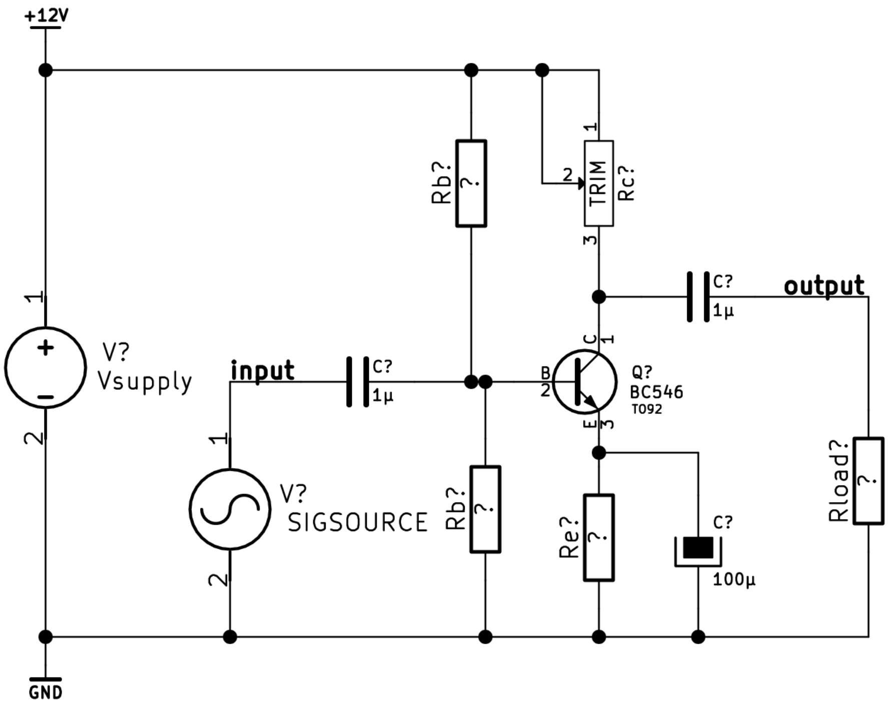


Figure 10: Voltage divider bias

### 6.0.4 "Noiseless" biasing

For small signals and high input impedance, the biasing can be improved further in terms of bias voltage "stiffness" and power supply noise rejection. The bias voltage is derived from a separate low impedance voltage divider, heavily filtered and almost a short circuit as far as AC signals are concerned. The bias voltage is tapped with a higher value resistor which effectively sets the input impedance of the stage.

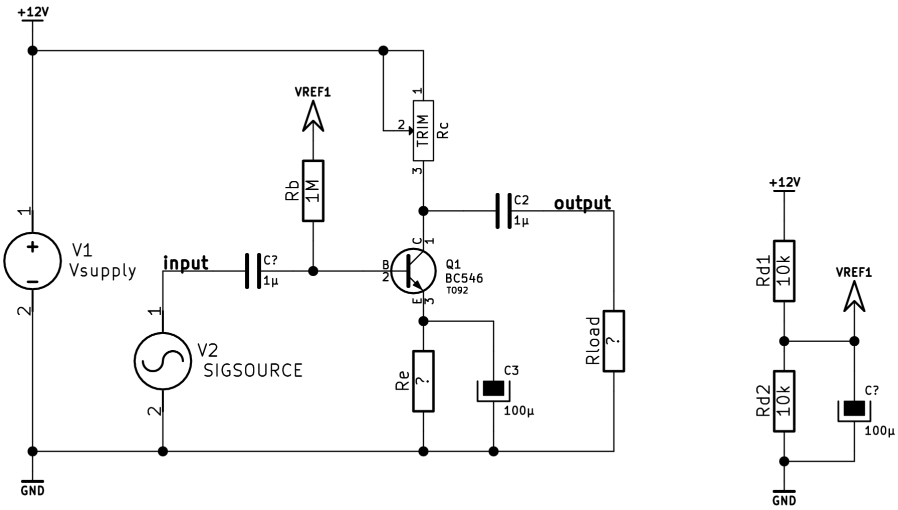


Figure 11: Voltage divider with filtered voltage reference