

Lab 138 - Transistors and Amplifiers

27 November 2014

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."

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1 Ic-Uce-characteristics

1.1 Circuit

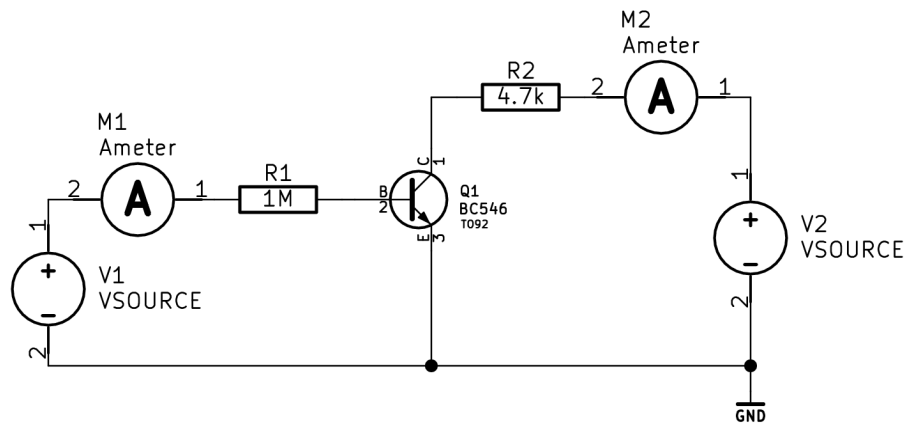


Figure 1: Measurement setup

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 I_b and in turn the collector current I_c . The transistor used is a BC547C.

1.1.2 Measurements

I_c (mA)	I_b (μ A)
0.5	1.14

Ic (mA)	Ib (μ A)
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.

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.

2 Quiescent conditions

2.1 Circuit

$E = 10V$ $R_c = 4.7k\Omega$

2.1.1 Curve

TODO

3 U_{ce}/I_b transfer function

Examine the output signal of the first circuit. Determine the linearity of the output, as in the relation of U_{ce} to I_b . Uses the measurement setup and circuit shown in Figure 1.

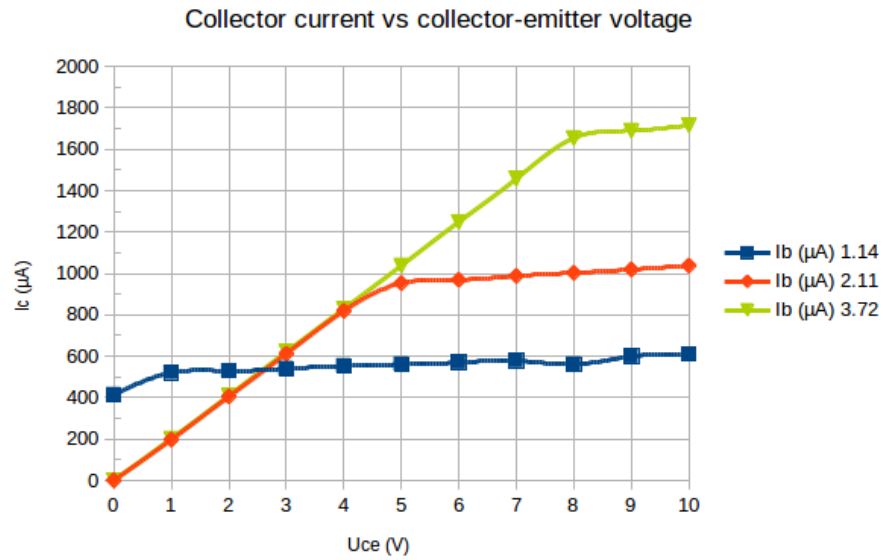


Figure 2: Ic-Uce results

4 Ic/Ib characteristics and current amplification

4.1 Measurements

4.2 Comments

TODO: Comment the curve, calculate current amplification factor $\Delta I_c / \Delta I_b$ in regions of interest.

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

Rb	Ve	Ve	Rc
1M Ω	00	00	00

Table 2: Bias resistor with bias voltages

6 BJT amplifier

6.0.1 Amplification

	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.

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.

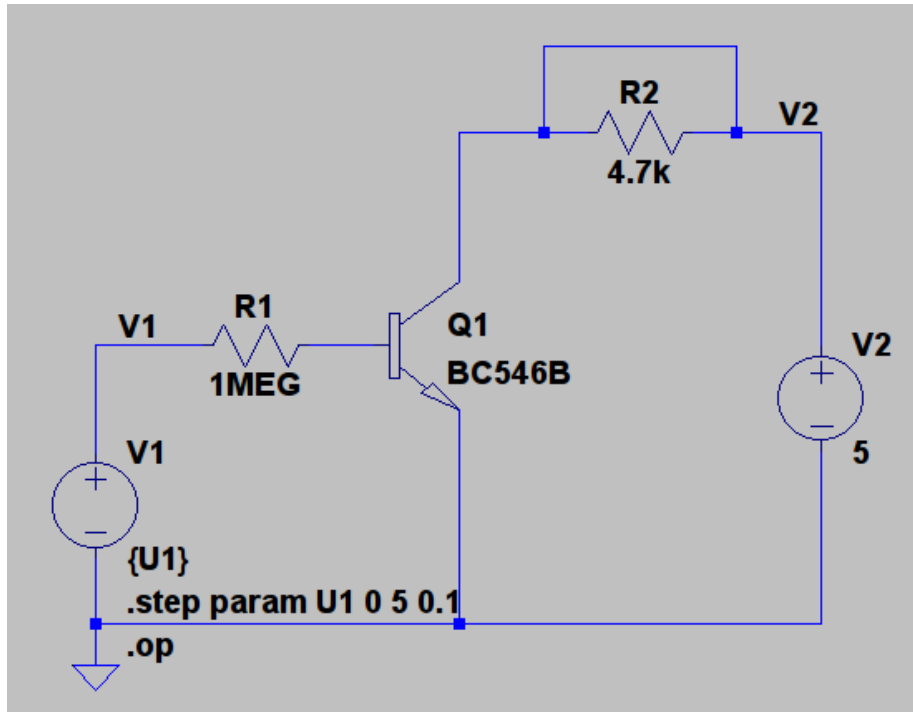


Figure 3: Ltpice schematic

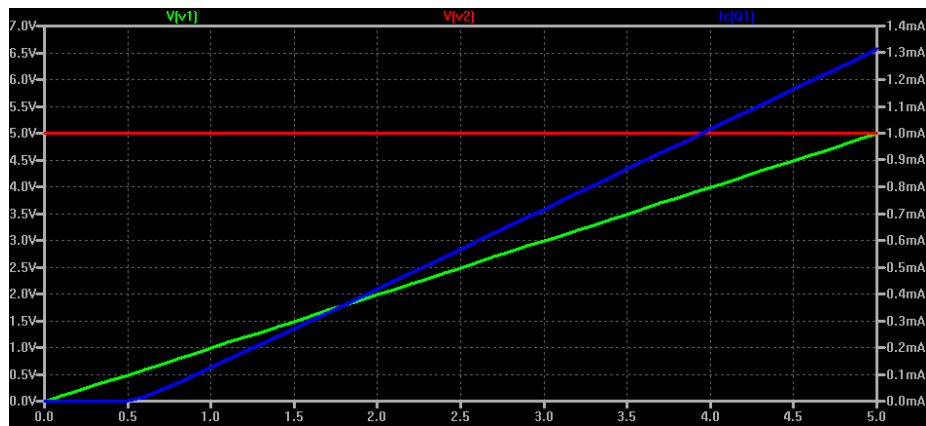


Figure 4: Ltpice simulation of Ic-Uce-characteristics

TODO!

Figure 5: TODO

TODO!

Figure 6: TODO

TODO!

Figure 7: I_c as a function of I_b

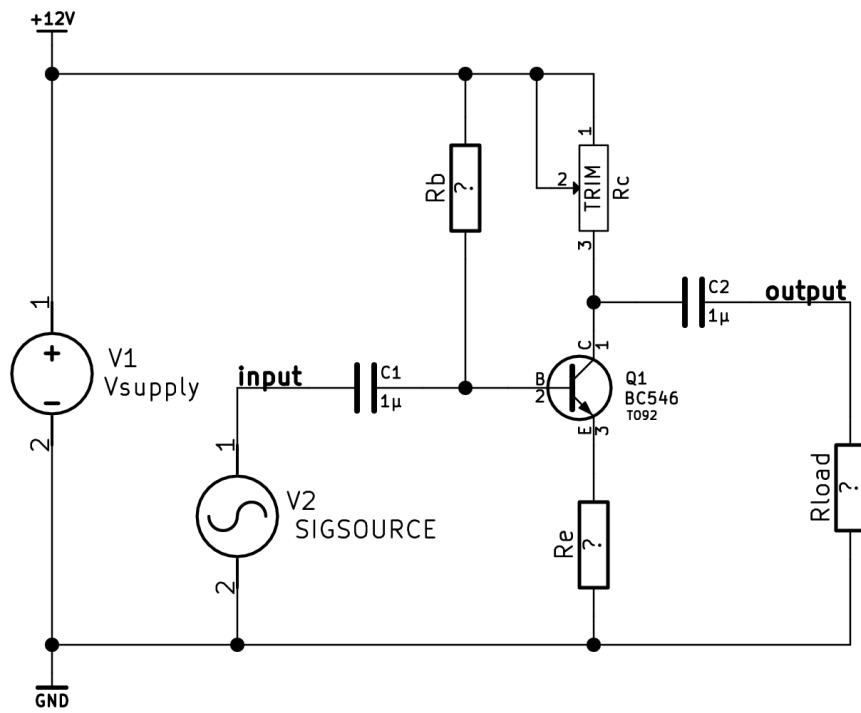


Figure 8: BJT biasing circuit

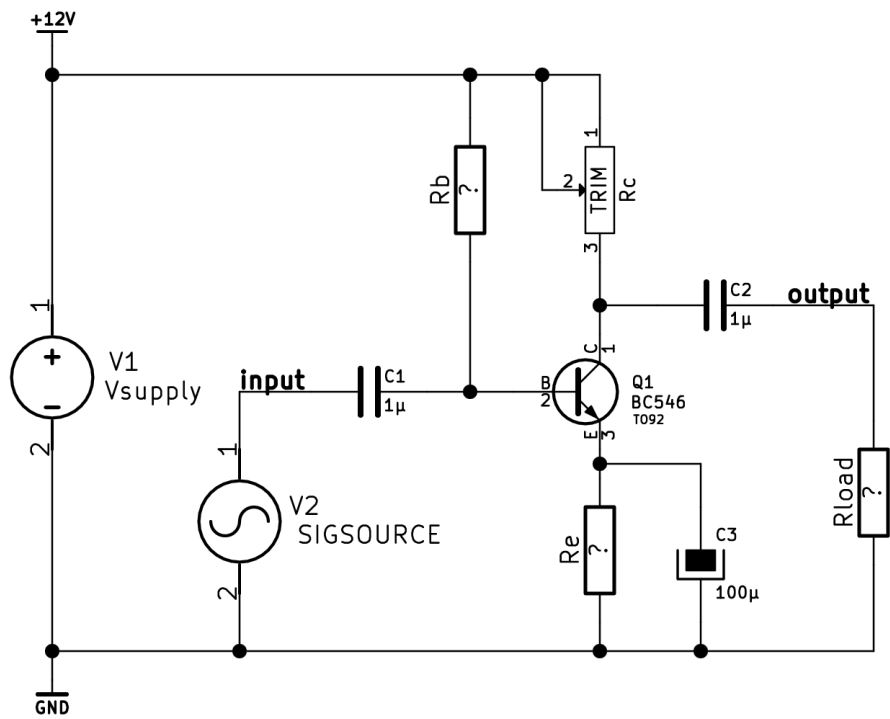


Figure 9: AC bypassed BJT amplifier

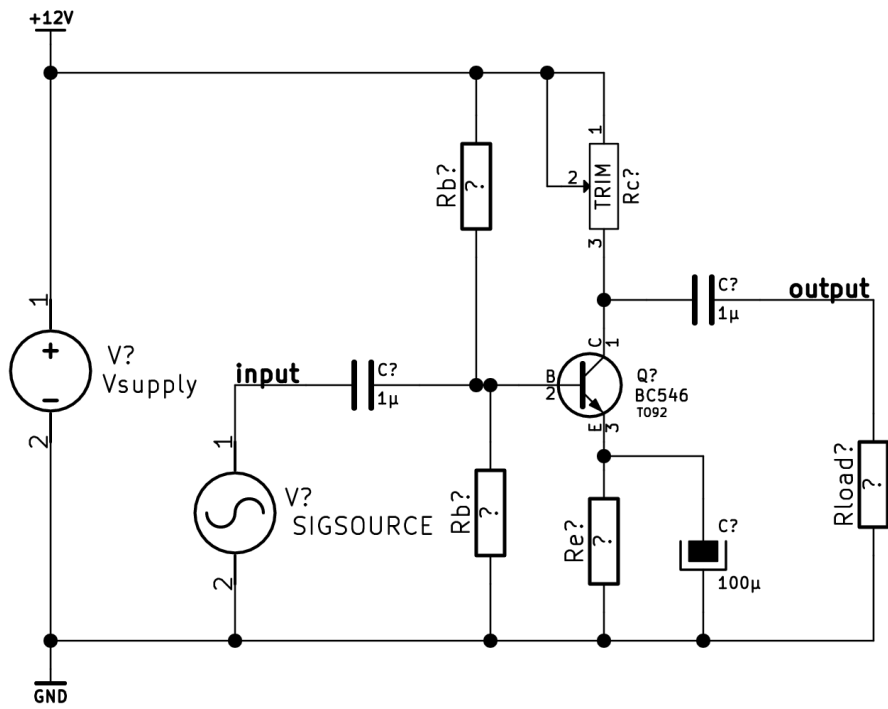


Figure 10: Voltage divider bias

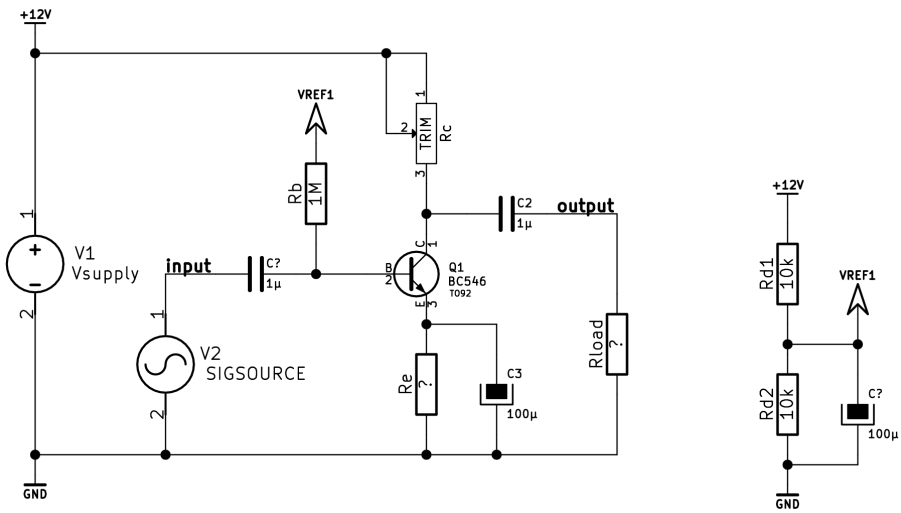


Figure 11: Voltage divider with filtered voltage reference