EE413
Lab 005
the Operational Amplifier

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Instructor: TODO

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."

1 Inverting DC Amplifier

1.1 Theory

The basic topology for an inverting amplifier is shown in 1. Gain, Av, can be expressed as a ratio of the feedback impedance to the input impedance. A fraction of the output is fed back, causing the op amp to compensate and in effect amplify.

$$A_v = \frac{R_2}{R_1} \tag{1}$$

The circuit gain for ideal components is therefore;
For $R_2 = 100k\Omega$:

$$A_v = \frac{V_{out}}{V_{in}} = -\frac{R_2}{R_1} \tag{2}$$

$$= \frac{100k\Omega}{10k\Omega} = 10 \tag{3}$$

$$= 20 \times \log \frac{10}{1} = 20dB \tag{4}$$

For $R_2 = 10k\Omega$:

$$A_v = \frac{V_{out}}{V_{in}} = -\frac{R_2}{R_1} \tag{5}$$

$$= \frac{10k\Omega}{10k\Omega} = 10 \tag{6}$$

$$= 20 \times \log \frac{1}{1} = 0dB \tag{7}$$

In both cases, the signal phase is inverted $180°$.

1.2 Measurements

Uin (V)	Uout (V)	Av (x)
-0.105	+1.087	-10.54
-1.008	+10.236	-10.15
+1.004	-10.104	-10.06

Table 1: R2 = 100kΩ

2
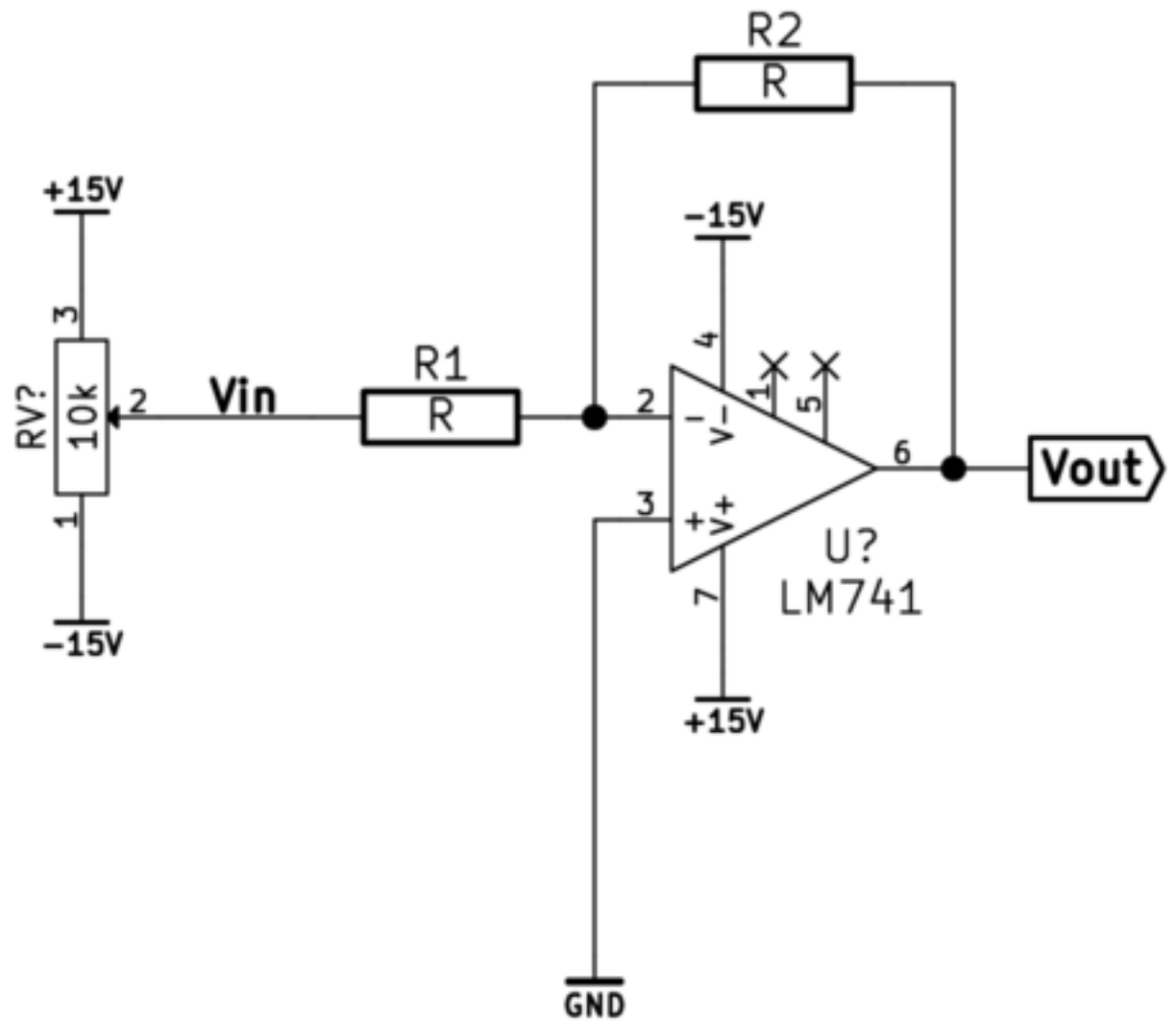
Figure 1: Inverting DC amplifier

Uin (V)	Uout (V)	Av (x)
-0.1051	+0.1051	-1
-1.008	+1.008	-1
+1.004	-1.004	-1

Table 2: R2 = 10kΩ

2 Inverting AC Amplifier

2.1 Oscilloscope shots

2.2 Measurements

Measured amplification = — Measured phase = 180 Theoretical amplifier = Theoretical phase =

3 Non-inverting DC Amplifier

Av = 1 + R2/R1

3.1 Measurements

Uin (V)	Uout (V)	Av (ggr)
+0.1007	+0.2164 2	.15
+1.002	+2.048 2	.04
-1.005	-2.03 2	.019

Table 3: R2 = 10kΩ

Uin (V)	Uout (V)	Av (ggr)
+0.1009	+1.178	11.67
+1.1013	+11.3	11.15
-1.004	-11.09	11.05

Table 4: R2 = 100kΩ

4 Non-inverting AC Amplifier

4.1 Measurements

Input signal amplitude =
Output signal amplitude =
Measured amplification =
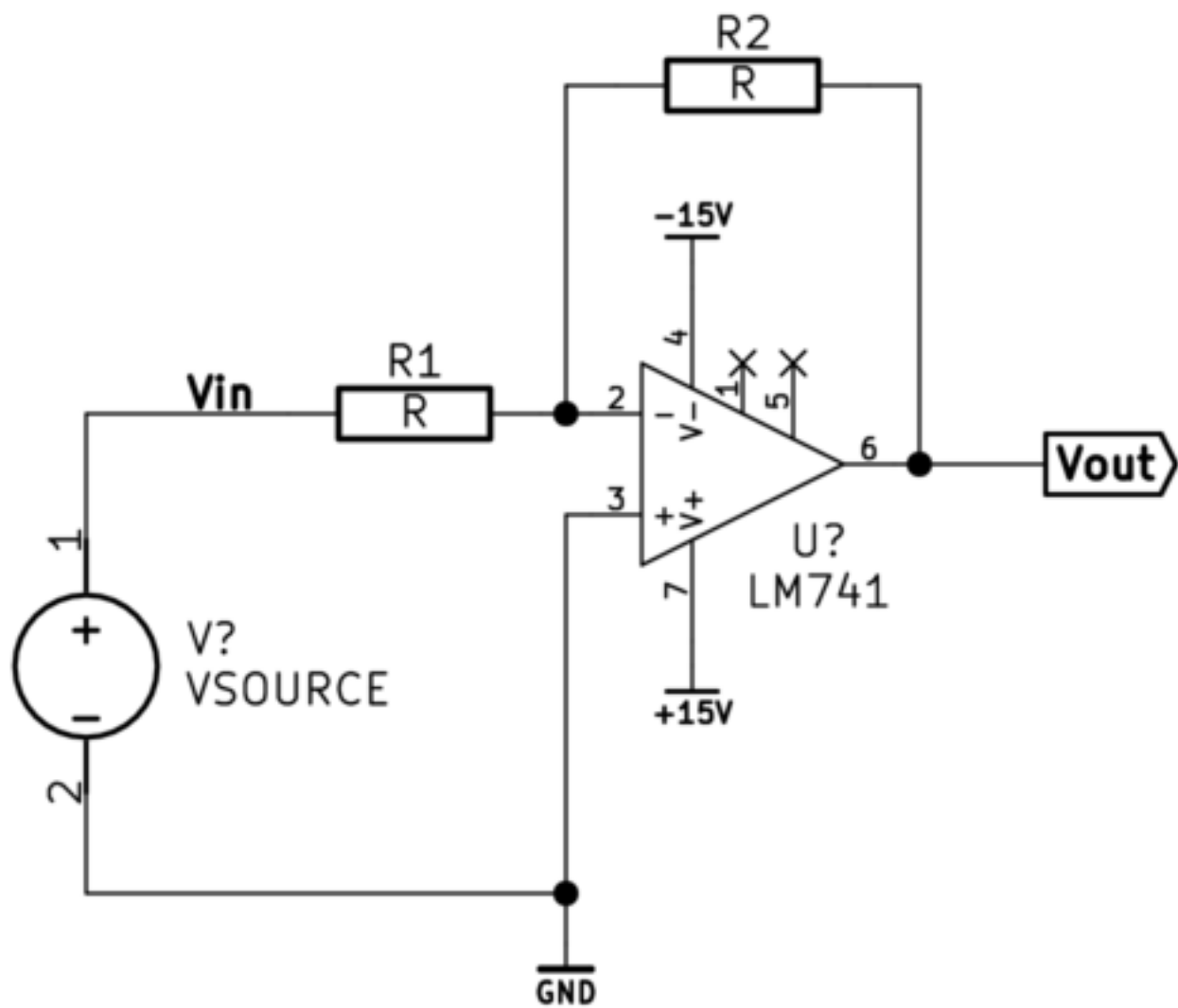Measured phase =
Theoretical amplification = Theoretical phase =
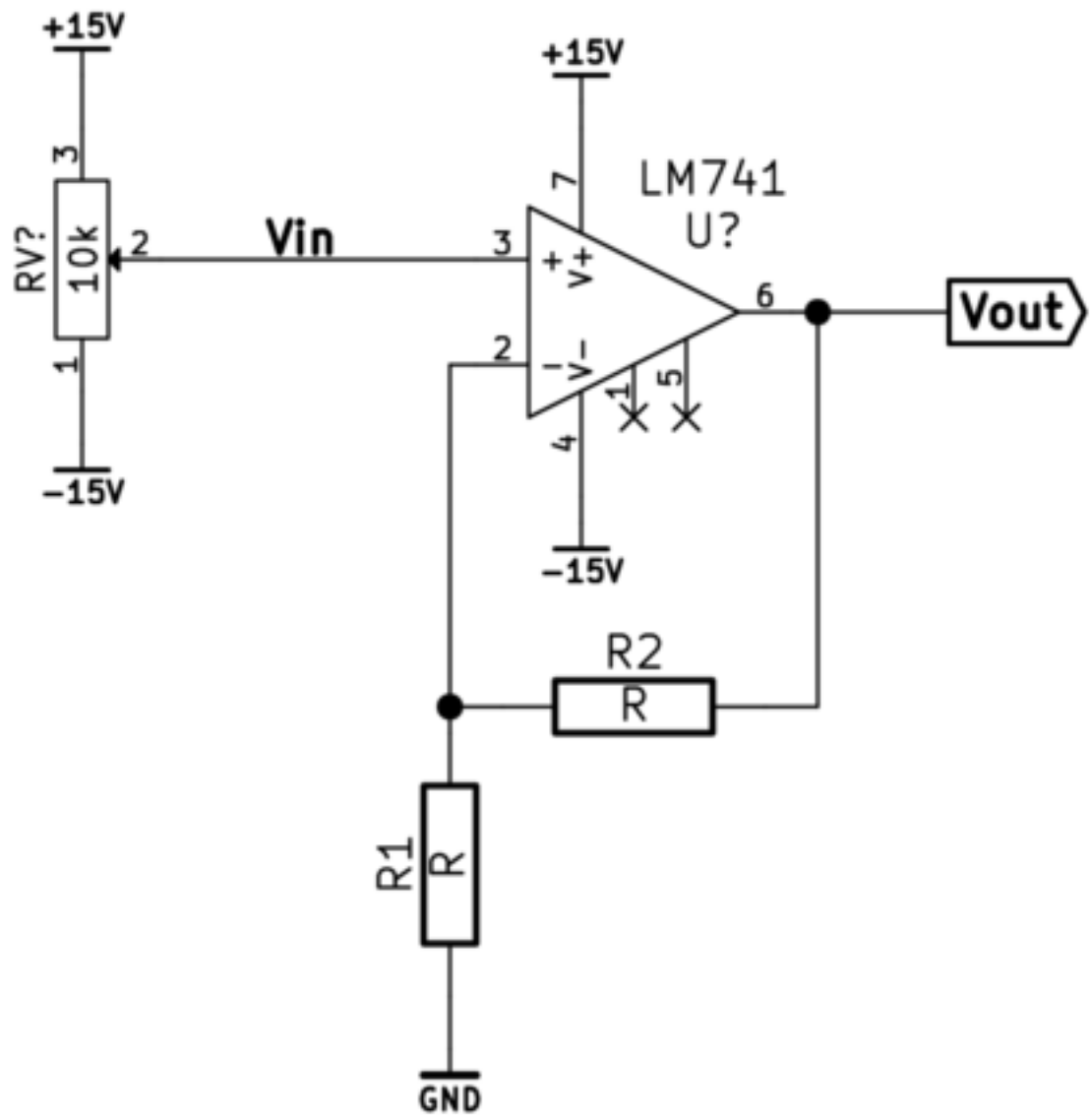
4

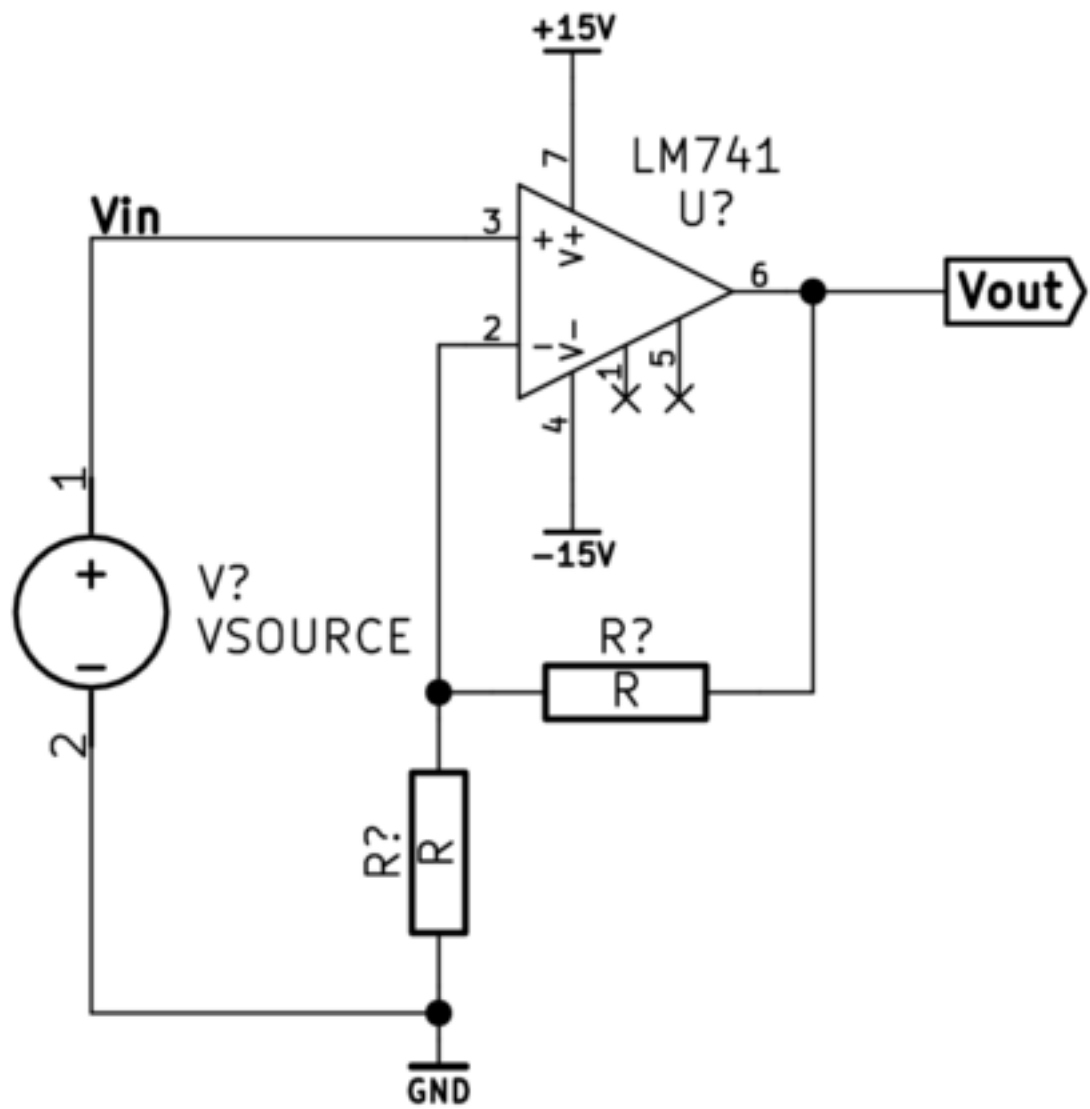Figure 2: Inverting AC amplifier

Figure 3: Non-inverting DC amplifier

Figure 4: Non-inverting AC amplifier

5   Active full wave rectifier

Active rectifier does not suffer from the "deadzone" when the signal is too small to turn on the rectifying diode. The op amp compensates for the diode forward voltage drop. The circuit output is a full wave rectified version of the signal, with a frequency limit mostly set by the op amp bandwidth. Diode D2 prevents the op amp from hitting the rail hard when D1 is reverse biased. This makes the recovery and rise time faster when D1 biases on. This improves circuit response times.