

First SPICE Exercise

Fundamentals Of Electronics - a.a. 2018-2019 - University of Padua (Italy)

Pietro Prandini (mat. 1097752)

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1 Audio amplifier

1.1 Voltage gain and frequency domain - Ideal op. amp.

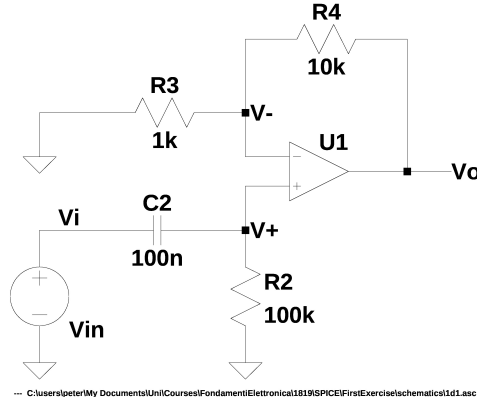


Figure 1: Audio amplifier - Ideal op. amp.

$$V_+ = V_{in} \frac{R_2}{R_2 + \frac{1}{sC_2}} = V_{in} \frac{R_2}{R_2 + \frac{1}{sC_2}} \frac{sC_2}{sC_2} = V_{in} \frac{sC_2 R_2}{1 + sC_2 R_2} \quad (1)$$

$$V_- = V_+ \quad (2)$$

$$I_{R_3} = \frac{V_-}{R_3} = \frac{V_+}{R_3} \quad (3)$$

$$I_{R_4} = I_{R_3} \quad (4)$$

$$V_o = V_+ + R_4 I_{R_4} = V_+ + R_4 I_{R_3} = V_+ + R_4 \cdot \frac{V_+}{R_3} = V_+ \cdot \left(1 + \frac{R_4}{R_3}\right) = V_{in} \frac{sC_2 R_2}{1 + sC_2 R_2} \cdot \left(1 + \frac{R_4}{R_3}\right) \quad (5)$$

$$\frac{V_o}{V_{in}} = \frac{sC_2 R_2}{1 + sC_2 R_2} \left(1 + \frac{R_4}{R_3}\right) \quad (6)$$

$$K = C_2 R_2 \cdot \left(1 + \frac{R_4}{R_3}\right) \quad (7)$$

$$\omega_1 = \frac{1}{C_2 R_2} \quad (8)$$

$$\frac{V_o}{V_{in}} = K \frac{s}{1 + \frac{1}{\omega_1 s}} \quad (9)$$

$$K|_{dB} = 20 \log_{10} |K| = \log_{10} \left| C_2 R_2 \cdot \left(1 + \frac{R_4}{R_3} \right) \right| = -19.1722dB \quad (10)$$

$$\omega_1|_{dB} = \log_{10} |\omega_1| = \log_{10} \left| \frac{1}{C_2 R_2} \right| = 2.0000dB \quad (11)$$

1.1.1 Bode diagram

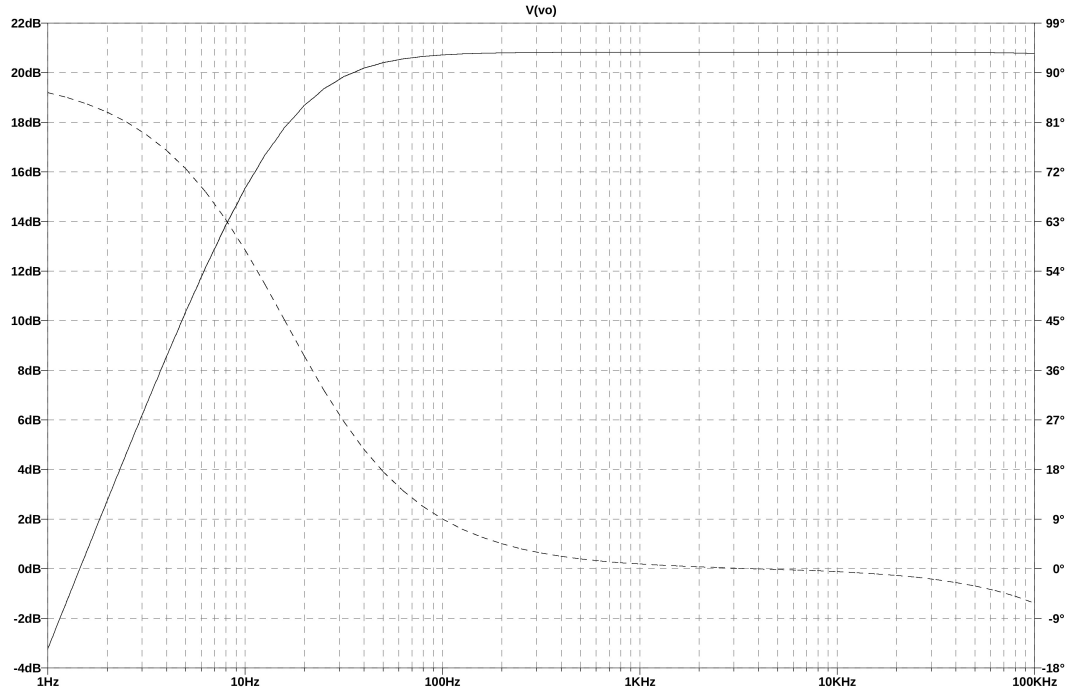


Figure 2: Audio amplifier - Ideal op. amp.

1.2 Voltage output waveform - LT1028 op. amp.

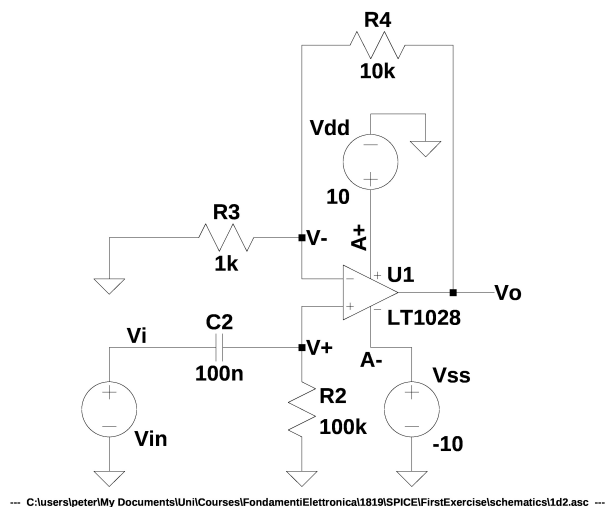


Figure 3: Audio amplifier - LT1028 op. amp.

1.2.1 Netlist

```

* Audio Amplifier – Waveform
*****
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*****

* Libraries
.LIB LTC.lib

* Amplifiers
XU1 V+ V– A+ A– Vo LT1028

* Capacitances
C2 Vi V+ 100n

* Generators
Vin Vi 0 DC 0 AC 1 sin(0 10mV {F} 0 0 0)
Vdd A+ 0 DC 10
Vss A– 0 DC –10

* Resistances
R2 V+ 0 100k
R3 V– 0 1k
R4 Vo V– 10k

* Analysis
.step param F list 1Hz 10Hz 100Hz
.tran 0 250m 0 1m uic

.END

```

1.2.2 Graph

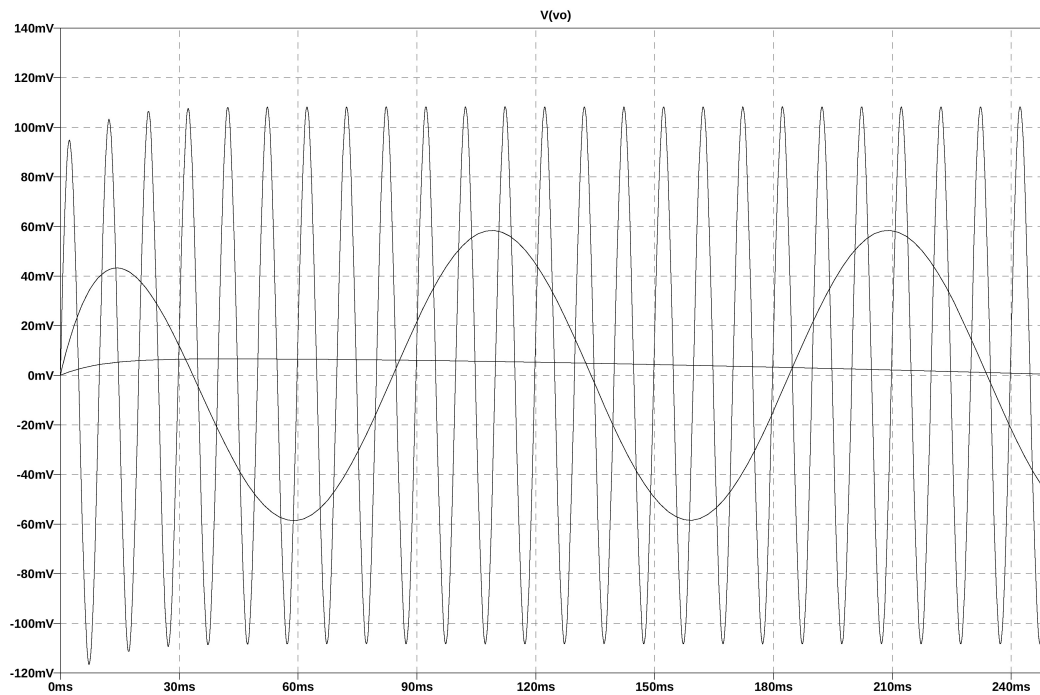


Figure 4: Audio Amplifier - Voltage output waveform

1.3 Bode diagram - LT1028 op. amp.

1.3.1 Netlist

```
* Audio Amplifier – Bode diagram
*****
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*****

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* Amplifiers
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* Capacitances
C2 Vi V+ 100n

* Generators
Vin Vi 0 DC 0 AC 1 sin(0 10mV {F} 0 0 0)
Vdd A+ 0 DC 10
Vss A- 0 DC -10

* Resistances
R2 V+ 0 100k
R3 V- 0 1k
R4 Vo V- 10k
```

```

* Analysis
.step param F list 1Hz 10Hz 100Hz
.ac DEC 10 1 100k

.END

```

1.3.2 Graph

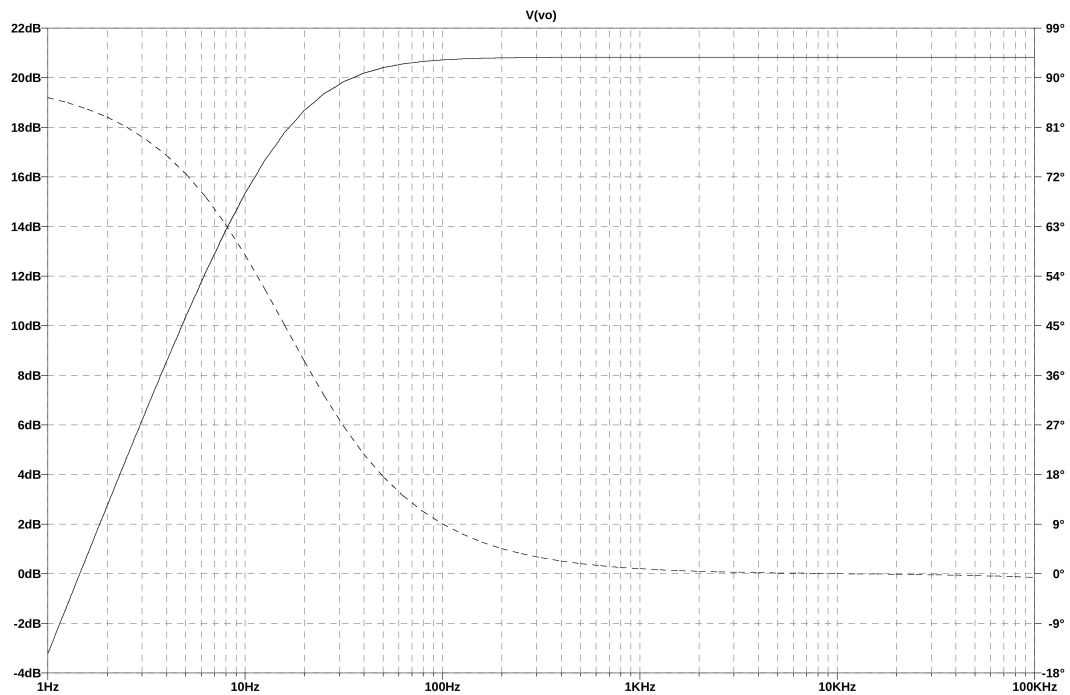


Figure 5: Audio Amplifier - Bode diagram