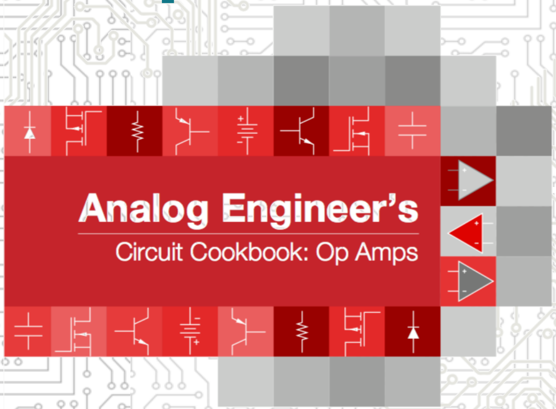
CIRCUIT060016

How to Design
Non-Inverting Microphone Pre-Amplifier Circuit



General Purpose Amplifiers

www.ti.com/general-amps

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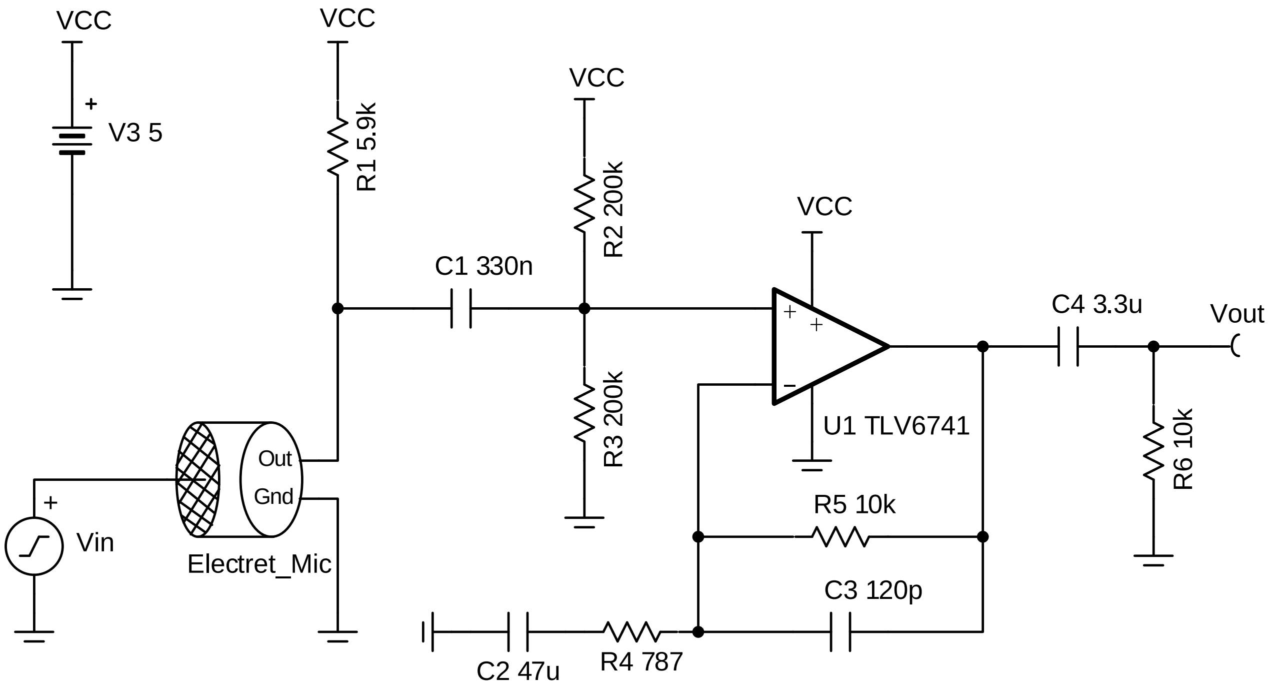
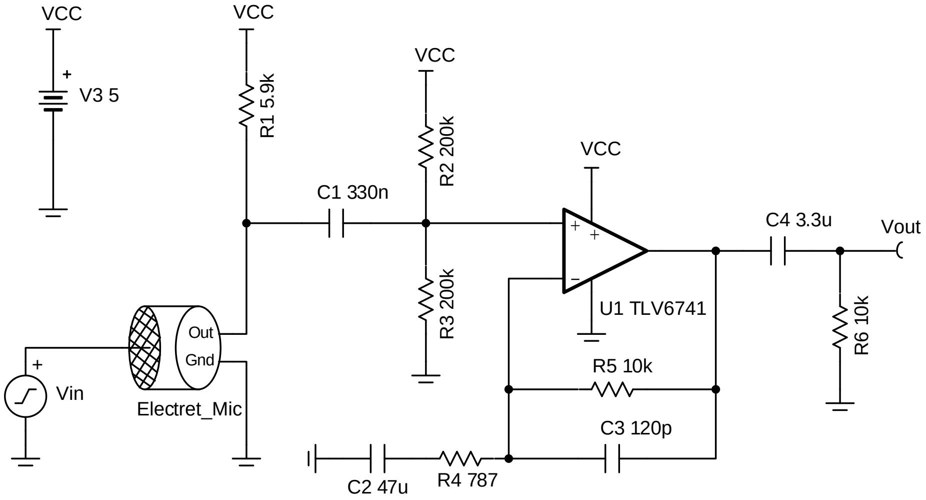
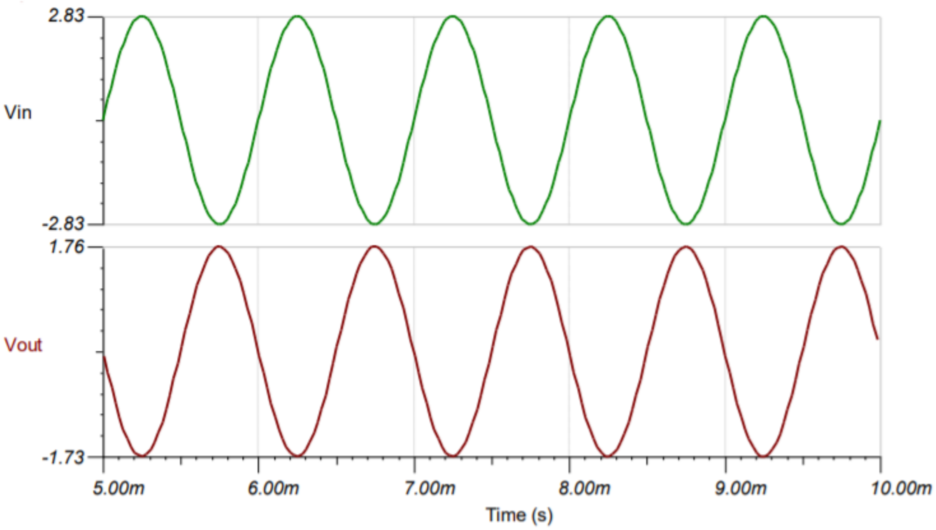
Circuit Description



Design Steps

Input Pressure (Max)	Output Voltage (Max)	Supply		Freq. Response Deviation	
		V_{cc}	V_{ee}	@20Hz	@20kHz
100dB SPL (2Pa)	$1.228V_{rms}$	5V	0V	-0.5dB	-0.1dB





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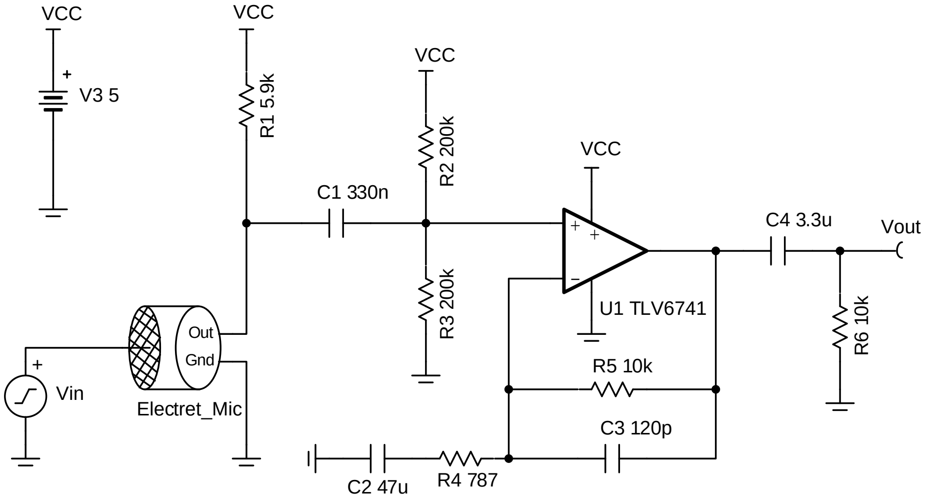

Microphone Parameter	Value
Sensitivity @94dB SPL (1Pa)	-35 dbV
Current Consumption (Max)	0.5mA
Impedance	2.2kΩ
Standard Operating Voltage	2Vdc

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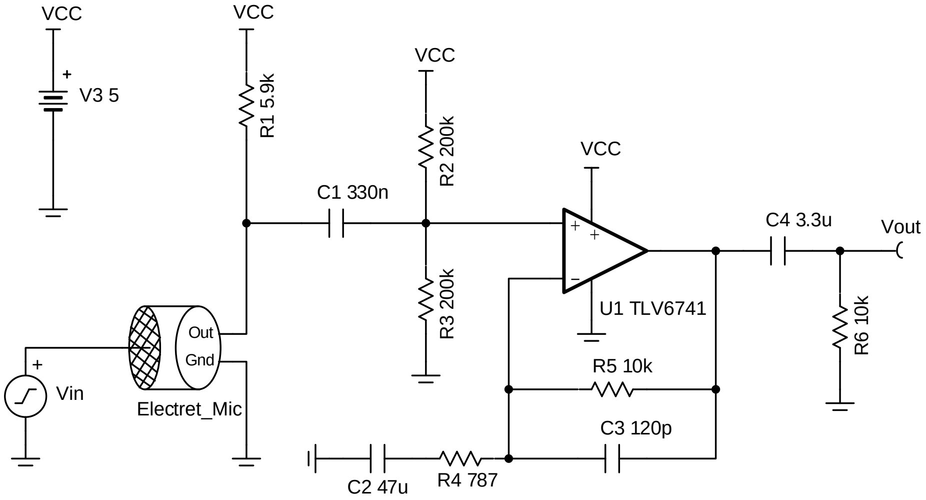

$$10^{\frac{-35dB}{20}} = 17.78\frac{mV}{Pa}$$

$$\frac{17.78\frac{mV}{Pa}}{2.2k\Omega} = 8.083\frac{\mu A}{Pa}$$

$$I_{Max} = 8.083\frac{\mu A}{Pa} \times 2Pa = 16.166\mu A$$

Design Steps

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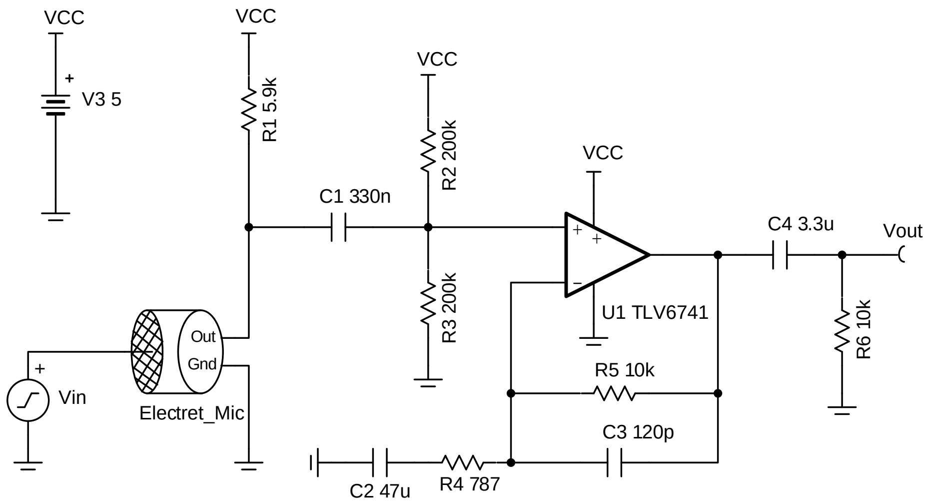

$$R_1 = \frac{V_{cc} - V_{mic}}{I_s}$$

$$R_1 = \frac{5V - 2V}{0.5mA} = 6k\Omega \approx 5.9k\Omega$$

Design Steps

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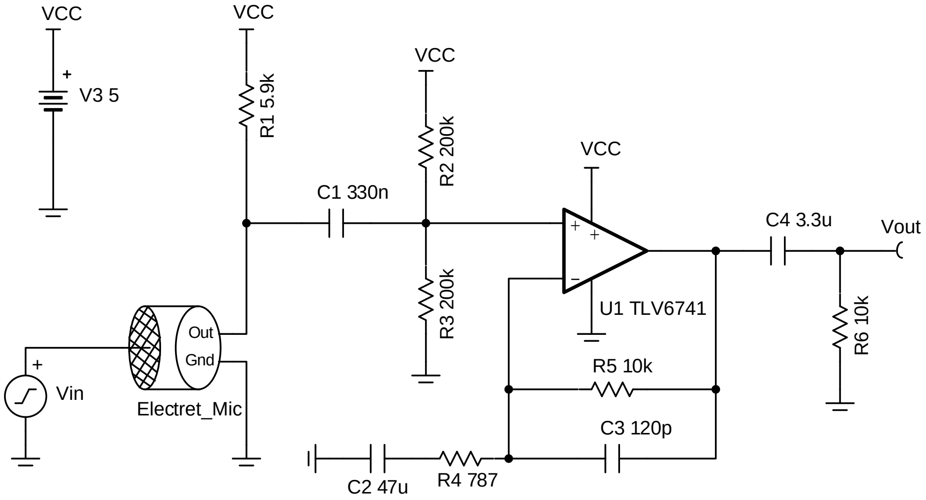

$$R_{eq} = R_2||R_3 > 10 \times R_1$$

$$R_2 = R_3 = 200k\Omega$$

Design Steps

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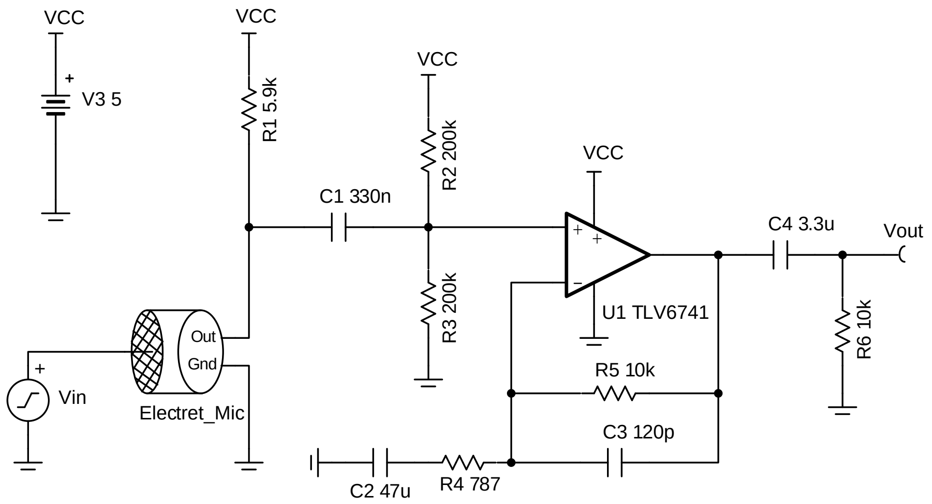

$$R_{in} = R_1 \Big|\Big| R_{eq} = 5.9k\Omega \Big|\Big| 100k\Omega = 5.571k\Omega$$

$$V_{in} = I_{max} \times R_{in}$$

$$V_{in} = 16.166\mu A \times 5.571k\Omega = 90.067mV$$

Design Steps

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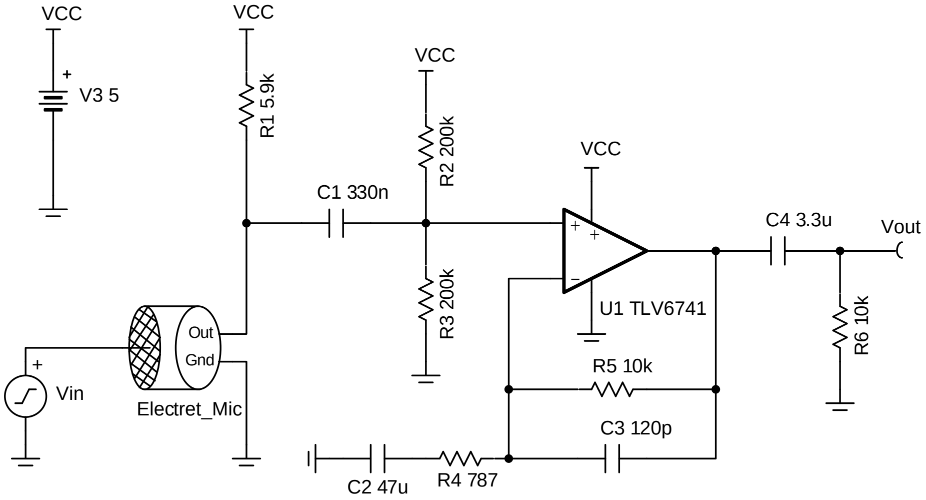
100dB SPL (2Pa)	$1.228V_{rms}$	V_{cc}	V_{ee}	@20Hz	@20kHz
		5V	0V	-0.5dB	-0.1dB



$$Gain = \frac{V_{outmax}}{V_{in}} = \frac{1.228V_{rms}}{90.067mV_{rms}} = 13.634\frac{V}{V}$$

$$R_4 = \frac{R_5}{Gain - 1}$$

$$R_5 = 10k\Omega$$

$$R_4 = 791\Omega \approx 787\Omega$$

Design Steps

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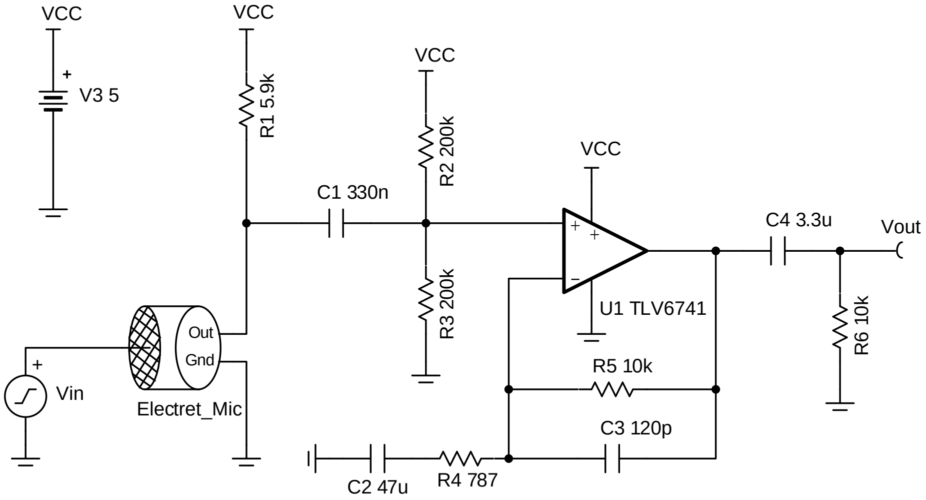

$$G_{Pole1} = 10^{\frac{-0.5/3}{20}}$$

$$f_c = f \times \sqrt{\left(\frac{1}{G_{pole1}}^2 - 1\right)} = 3.956Hz$$

$$C_1 = \frac{1}{2\pi \times R_{eq} \times f_c} = 0.402\mu F \approx 0.33\mu F$$

$$C_2 = \frac{1}{2\pi \times R_4 \times f_c} = 51.121\mu F \approx 47\mu F$$

$$C_4 = \frac{1}{2\pi \times R_6 \times f_c} = 4.023\mu F \approx 3.3\mu F$$

Design Steps

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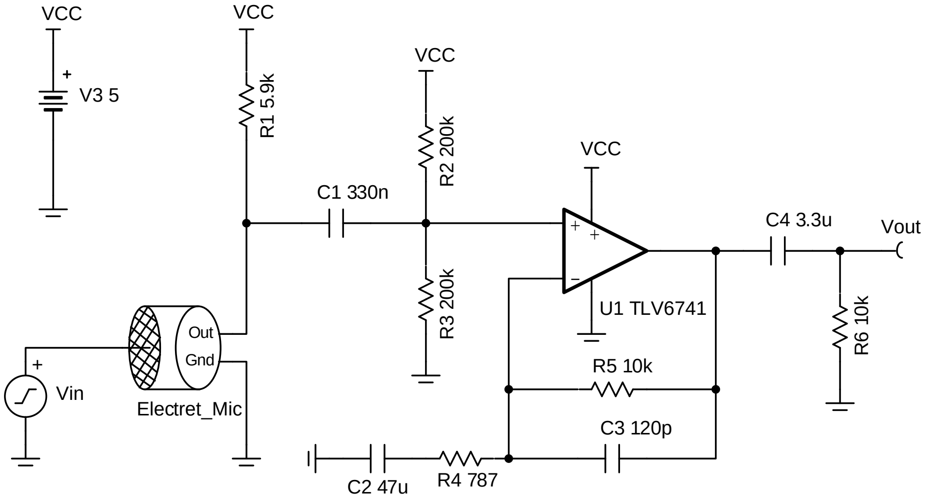


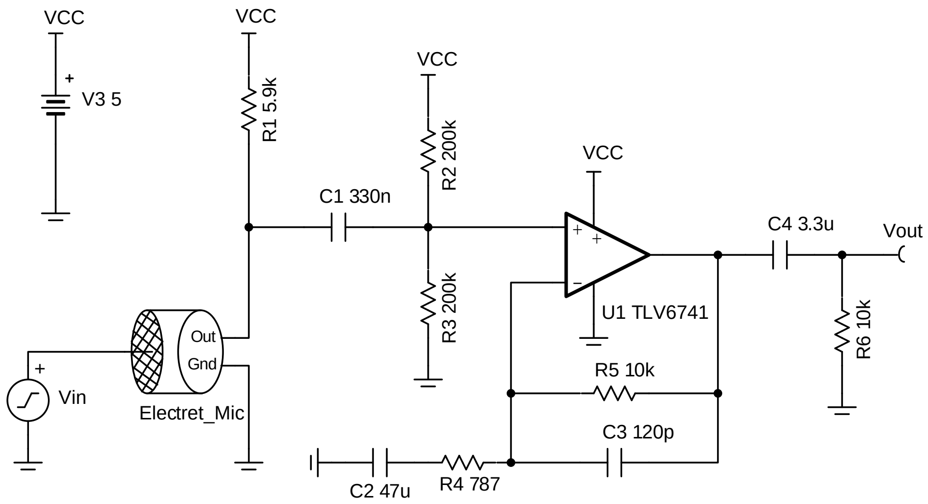
$$G_{pole2} = 10^{\frac{-0.1}{20}}$$

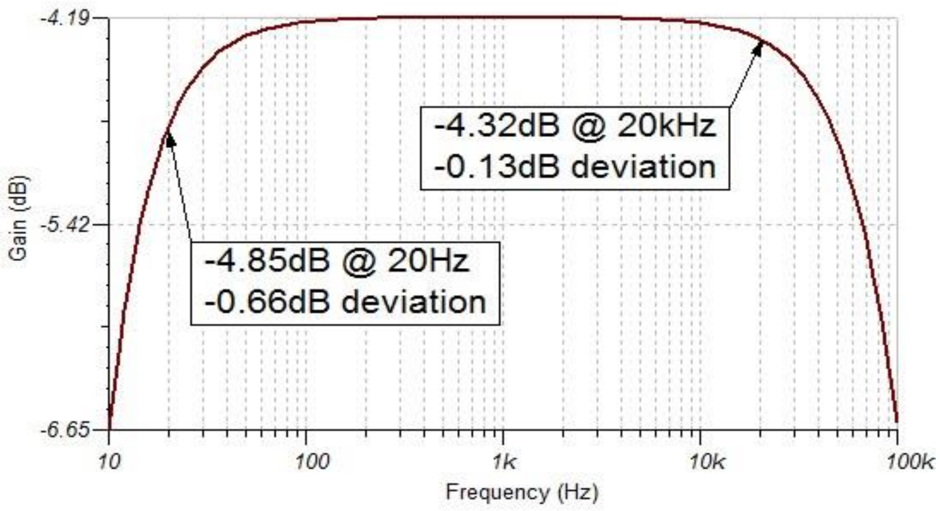
$$f_p = \frac{f}{\sqrt{\left(\frac{1}{G_{pole2}}^2 - 1\right)}} = 131.044kHz$$

$$C_3 = \frac{1}{2\pi \times R_5 \times f_p} = 121.451pF \approx 120pF$$

AC Results

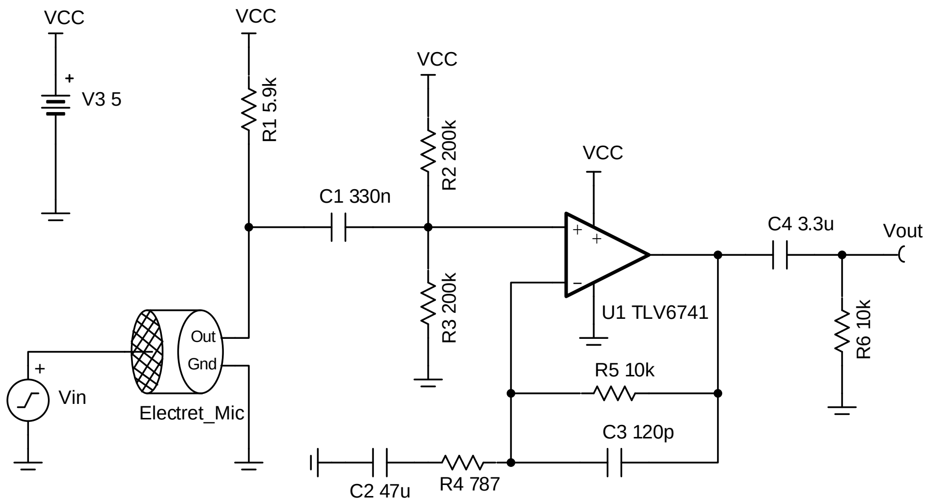
Input Pressure (Max)	Output Voltage (Max)	Supply		Freq. Response Deviation	
		V_{cc}	V_{ee}	@20Hz	@20kHz
100dB SPL (2Pa)	$1.228V_{rms}$	5V	0V	-0.5dB	-0.1dB

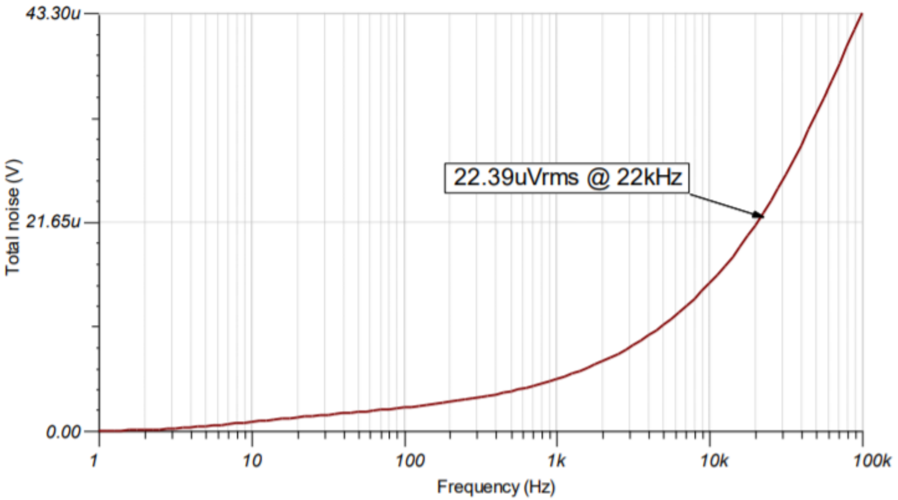




Noise Results

Input Pressure (Max)	Output Voltage (Max)	Supply		Freq. Response Deviation	
		V_{cc}	V_{ee}	@20Hz	@20kHz
100dB SPL (2Pa)	$1.228V_{rms}$	5V	0V	-0.5dB	-0.1dB





Design Notes

Input Pressure (Max)	Output Voltage (Max)	Supply		Freq. Response Deviation	
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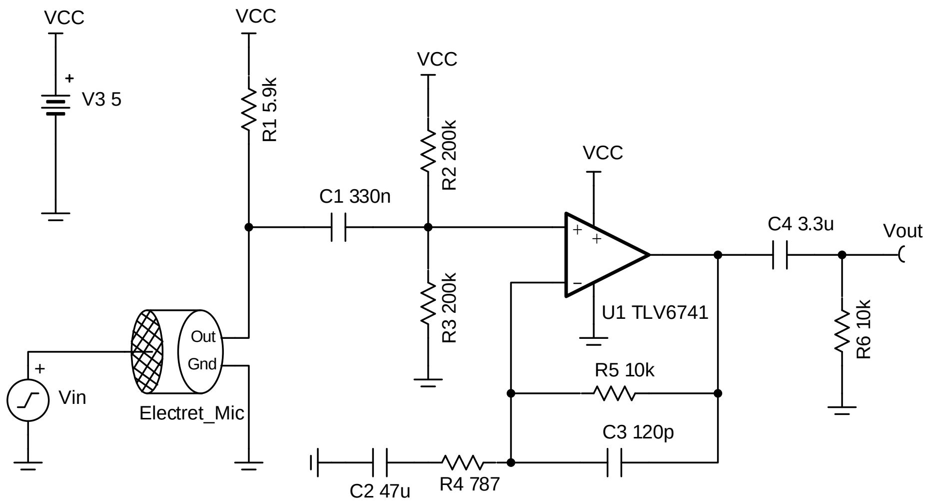

Design Notes:

1. Use low–K capacitors (tantalum, C0G, and so forth) and thin film resistors help to decrease distortion.
2. Use a battery to power this circuit to eliminate distortion caused by switching power supplies.
3. The common mode voltage is equal to the DC bias voltage plus any variation caused by the microphone output voltage. For op amps with a complementary pair input stage it is recommended to keep the common mode voltage away from the cross over region to eliminate the possibility of cross over distortion.

Design Resources

EE Cookbook: Op Amp
www.ti.com/circuitcookbooks
Step-by-step circuit design of common op amp building block circuits.

TI Designs
www.TI.com/tidesigns
Ready-to-use reference designs with
theory, calculations, simulations
schematics, PCB files, bench test results

Analog Engineer's Pocket Reference
www.TI.com/analogrefguide
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PCB, analog, mixed signal design formulae
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Evaluation module providing engineers with SC70, SOT23, SOIC packaging and 12 popular amplifier configurations

The Signal
www.TI.com/thesignal
PDF, iTunes app and hardcopy available
A compendium of blog posts on op amp design topics including
offset voltage, input bias current, stability, noise and more

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Tips, tricks, and design techniques

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