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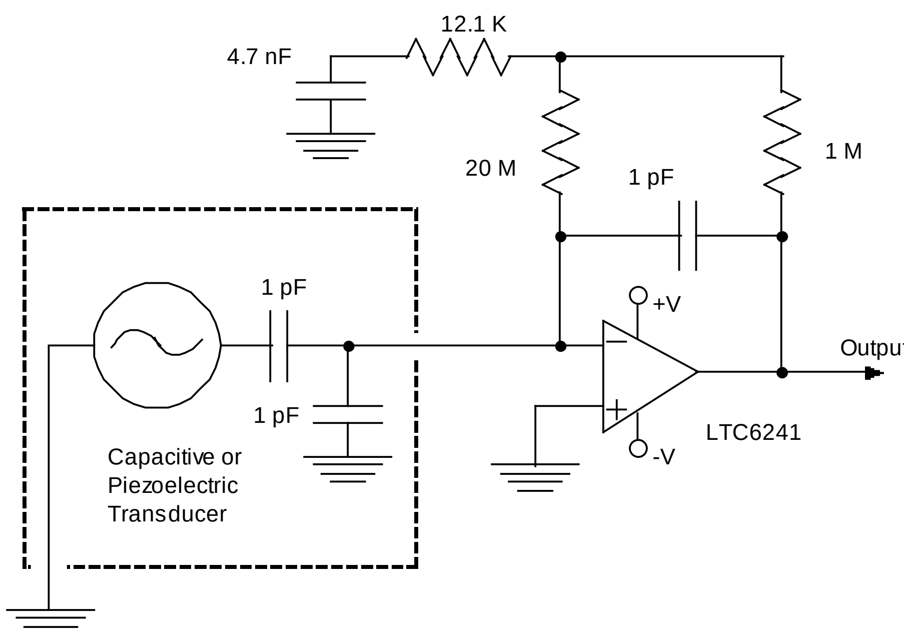
Useful Design 003:

Charge Amplifier With Stable Gain and Phase:

Charge amplifiers are used with capacitive and piezoelectric sensor sources.
The ideal form is an integrator, but this is impractical because the integrator will drift over time. Adding a feedback resistor to the circuit is the classical way to limit this drift, but using a low resistance will limit the bandwidth and conversely using a large resistance causes larger biases.

The circuit below provides near ideal response from 2 KHz to 200 KHz in both gain and phase.



The effective resistance in the feedback circuit is 1,673 MΩ for AC signals. The DC feedback resistance is 21 MΩ for the purpose of bias control. This high AC feedback resistance is because the 4.7 nF capacitor is effectively an AC short circuit. Therefore, only about 1.2 % of the feedback current will travel through the 20 MΩ feedback resistor, making the effective AC resistance 1,673 MΩ.

This condition makes a “sweet spot” in the response curves as shown below:

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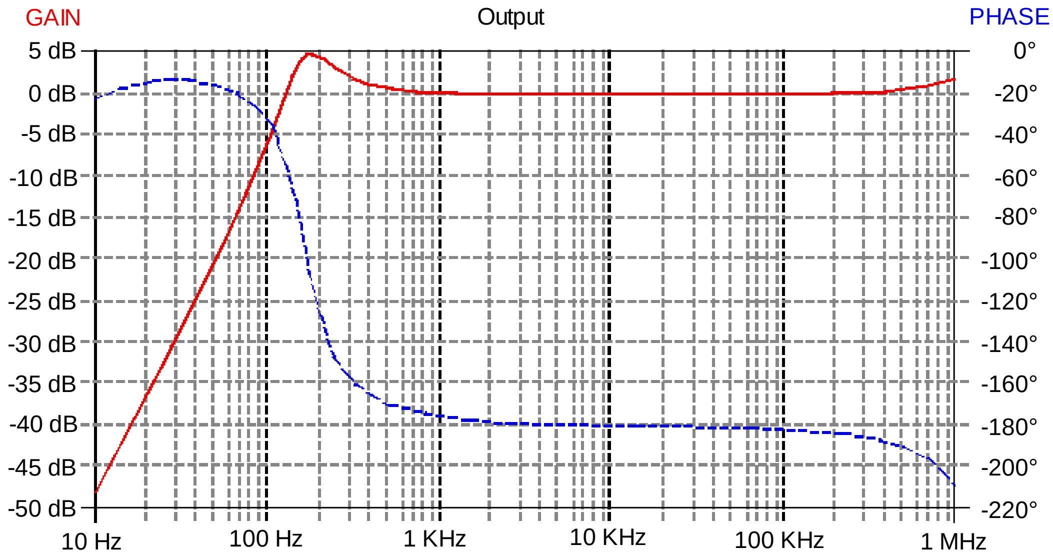
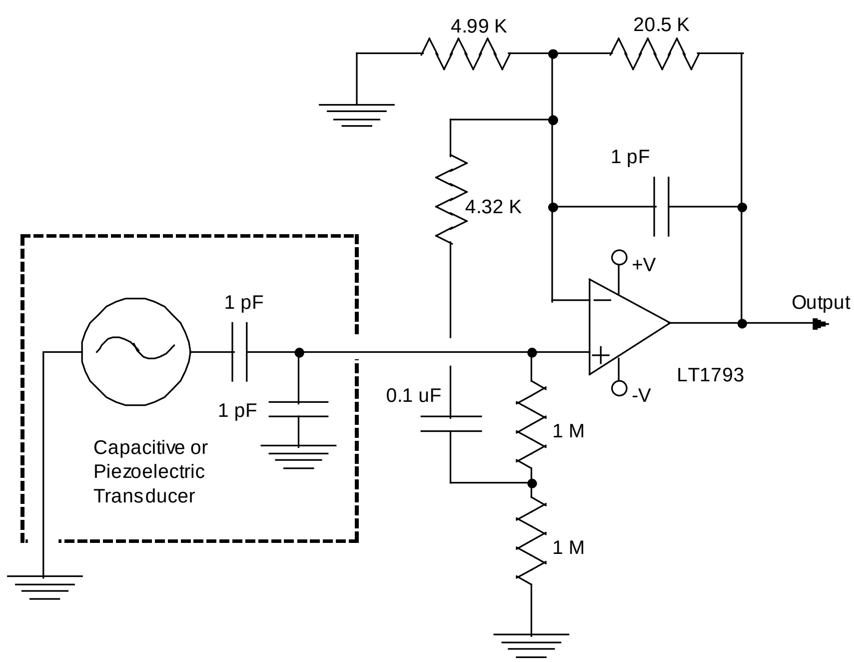


A follower circuit with stable gain and phase.

The feedback of a charge amplifier effectively shorts out the transducer output in its operation. If loading of the transducer is a problem, a follower circuit may be the answer. Fortunately, the same principles of attenuating the feedback (shown above) will also work for a follower circuit:



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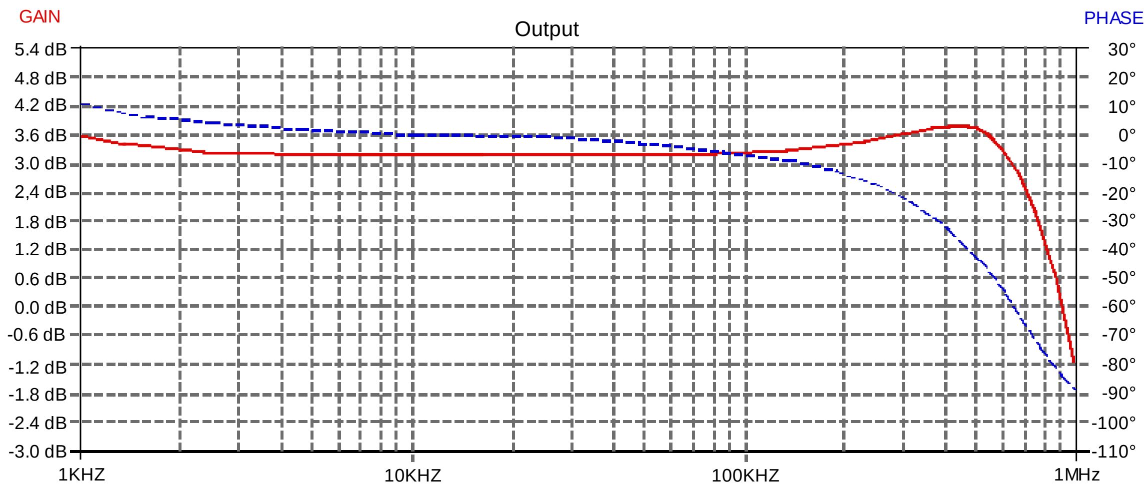
This circuit has an overall voltage gain of just over 2 and an AC input impedance of 234 MΩ. This impedance stays relatively constant over 2 KHz to 100 KHz.



A high AC feedback resistance is achieved by using the same kind of leveraging that was used in the charge amplifier. The minus input to the op-amp is driven by the feedback circuit to be a voltage that is equal to the plus input. The 0.1 uF capacitor in this circuit acts as an AC short circuit. Therefore, the 4.32 KΩ resistor has only 0.43% of the AC input voltage across it. As a result, the AC current through the 1 MΩ resistor at the plus op-amp input is similarly lower, creating an effective AC input impedance of 234 MΩ.

These circuits are commonly used for capacitive proximity sensors. This type of circuit can also be used for accelerometers, solid state gyros, balancing machines and much more.

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