Fast, low-noise JFET amp is stable over temperature

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While JFETs are excellent devices for low-cost high-input impedance amplifiers, they do suffer from temperature-dependent gain drift. This problem can be ameliorated by setting the drain current to the zero-drift operating point over the -55°C to 125°C temperature range.

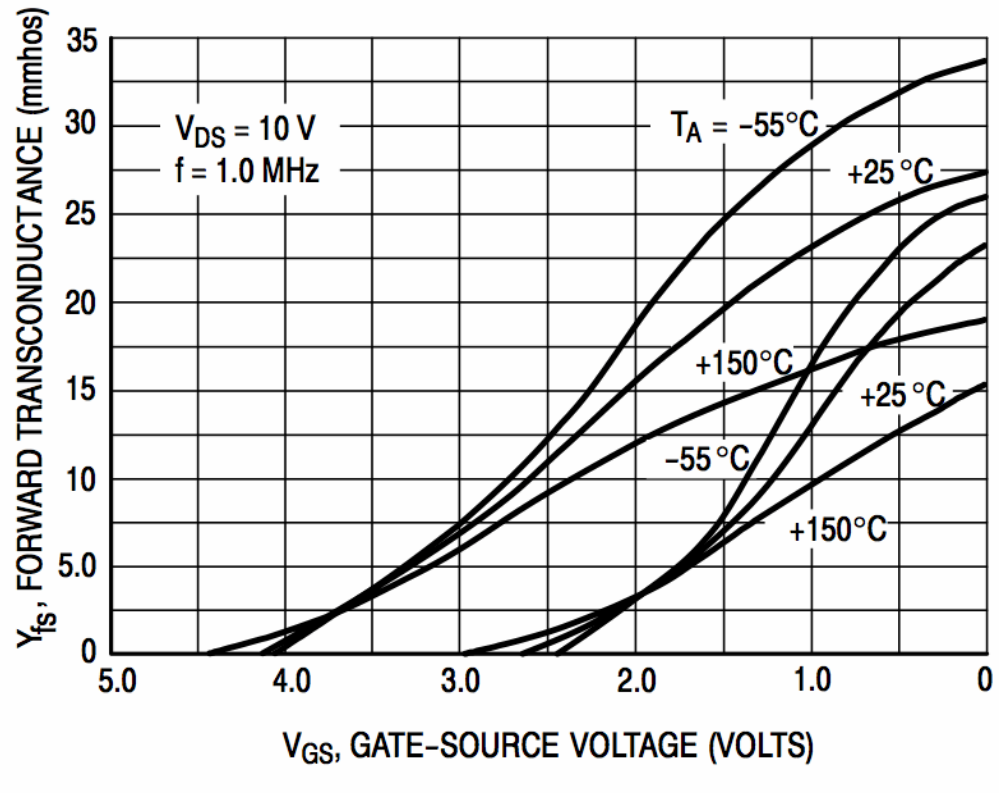

Figure 1 Transconductance curve families over temperature for J310 & J309 JFETs (OnSemi)

Various JFETs have been tested for this Design Idea circuit: Sony 2SK152-2, Interfet IFN152, and Siliconix/Vishay/OnSemi J309, as they have high gain and a low gate leakage current of about 100pA. These JFETs are well suited to 1MΩ- to 1GΩ-input impedance amplifier design. The circuit works well to over 100MHz.

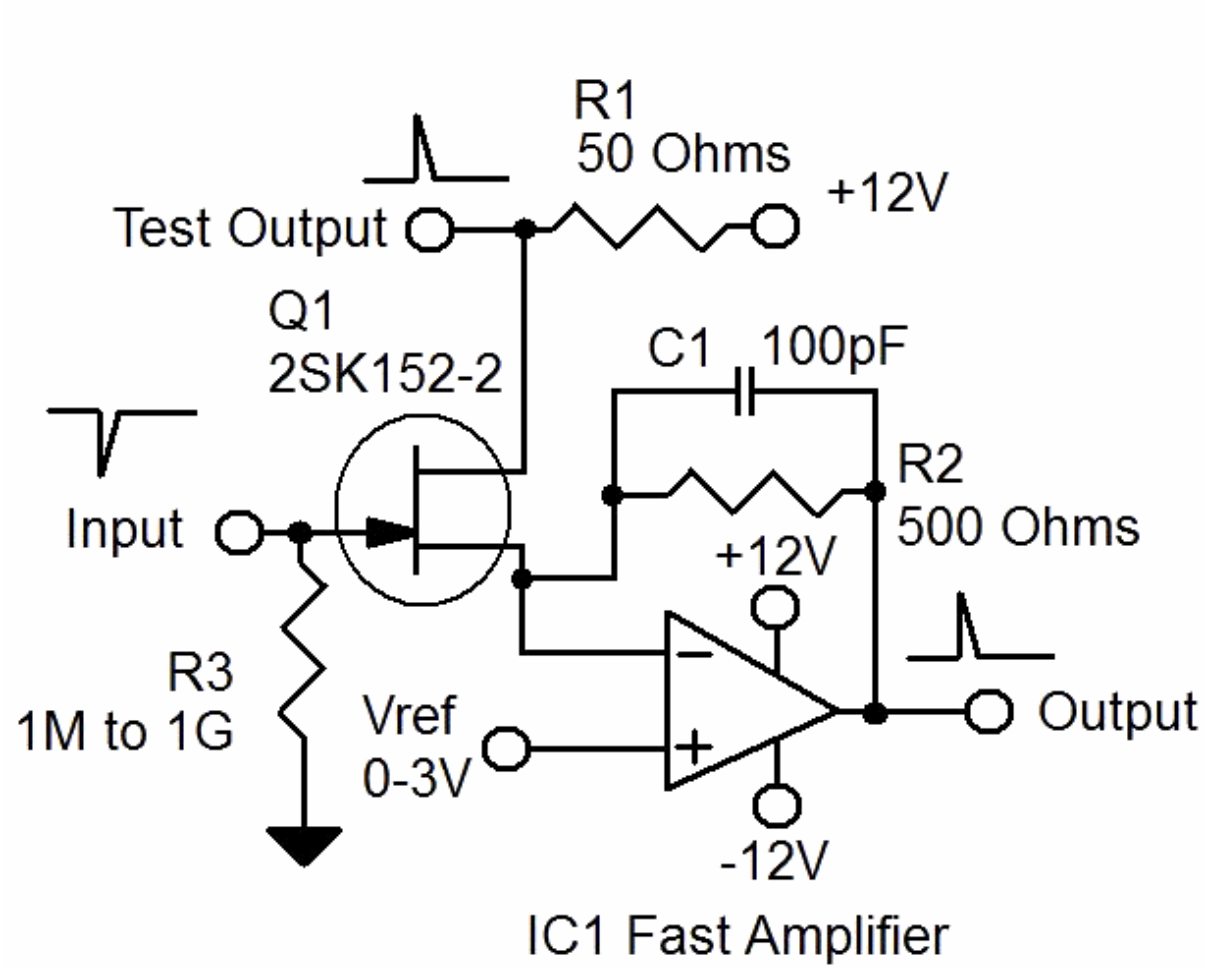

Figure 2 Very wide temperature range, gain-stable, fast JFET high-impedance amplifier

One advantage of the circuit comes from its large operating temperature range (-55°C to 125°C for the JFET). IC1 can be kept at room temperature, linked by a few feet of PTFE coax for example, for temperature isolation. Thus the JFET can be mounted in a very cool environment for lowest noise, which was a primary objective of the design.

The input signal to JFET Q1 is fed to its gate, which is biased to ground through R3 (which could be a lower value in the case of a current-source input).

The JFET's source is biased through the inverting current-to-voltage stage based on IC1. V_{ref}, which controls the quiescent V_{GS}, is set between 0V & 3V for most JFETs to set the drain current at the zero-drift midpoint, which also gives a large dynamic range for the input signal. By adjusting V_{ref}, we can bring Q1's operating current to about 7mA-10mA, which is close to the zero-drift point. The operating current has to be separately analyzed for each JFET to be set properly. For the 2SK152-2, it was found to be 7.5mA ±1mA for the 1,000 JFETs I have tested.

IC1 is a fast CFA (current-feedback amplifier): Analog Devices' AD812 at ±12V to ±15V, and AD8009 at ±5V, have been used successfully. The feedback resistor R2 can be from 500Ω to 5kΩ, in parallel with C1 of 100pF to avoid oscillations and overshoot. Remember that the output of the amplifier has a voltage offset due to the biased input stage and hence is best suited to AC or pulsed signals. A risetime of 10ns to 100ns is feasible with the proper R2/C1 combination. CFAs are

operated within a gain range of 2-10, set by resistor R2; at much higher gains, the amplifier starts oscillating.

R1 provides a test output to measure the current through the JFET. It also generates a fast 50Ω output which can be directly connected to an oscilloscope. Both output signals are inverted compared to the input signal – typically ±100mV. For DC-biased signals, a coupling capacitor of about 1nF-10nF can be used in front of the gate.

Also see:

- A guide to using FETS for sensor applications, Part 1
- Condenser microphone uses dc-coupled impedance converter
- Product How-to: LSK489 Application Note
- Simple circuit lets you characterize JFETs
- Op amps make JFET circuits repeatable