Input bias current of CMOS and JFET amplifiers

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COMMENT 1 < HTTPS://WWW.EDN.COM/INPUT-BIAS-CURRENT-OF-CMOS-AND-JFET-AMPLIFIERS/#COMMENTS>

BY BRUCE TRUMP < HTTPS://WWW.EDN.COM/AUTHOR/BRUCE-TRUMP/>

CMOS and JFET-input op amps are often selected for their low input bias current (I_B). But there is more to the story than the single line in a spec table—subtleties that you should be aware of.

The gate of a CMOS transistor (the working input of a CMOS op amp) has extremely low input current. But these fragile gates must be protected from ESD and EOS < http://e2e.ti.com/support/amplifiers/precision-amplifiers/w/design-

notes/2189.electrical-over-stress-and-electrostatic-discharge-protection-of-ics.aspx> with additional circuitry that is the primary source of their input bias current. This protection generally includes internal clamp diodes to the supply rails. The OPA320 < http://www.datasheets.com/search/partdetail/opa320aidbvt/texas-instruments> is an example in figure 1a. These diodes have a small leakage current in the few picoamp range. At an input voltages near mid-supply rails, their leakages are is pretty well matched, leaving only a small residual difference current of less than 1pA that appears as amplifier input bias current.

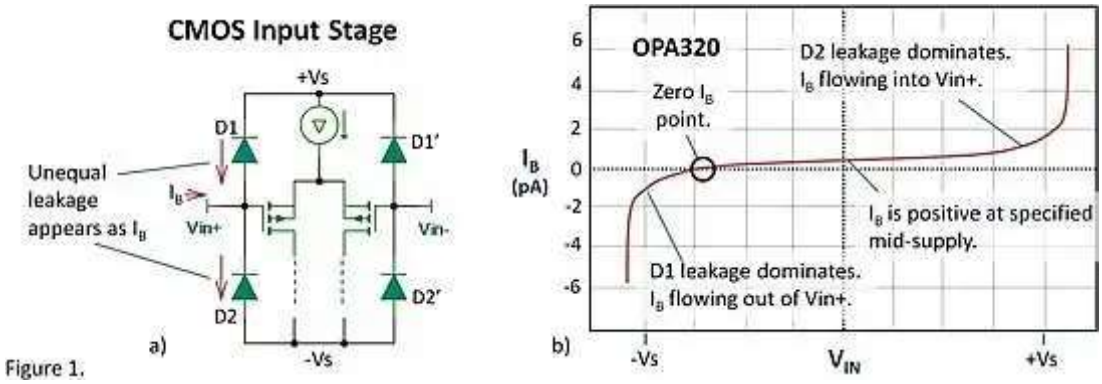


Figure 1.

The relationship of the two diode leakages changes as the input voltage nears the supply rails. Near the bottom rail, for example, D2's reverse voltage nears zero and its leakage is reduced. D1's leakage will dominate causing a higher input bias current flowing out of the input terminal. Of course, the opposite occurs as the input approaches the positive supply rail. The input bias current is specified and tested at the midpoint where leakage is nearly matched and quite low.

The result is an input bias current vs. input voltage that varies as shown in figure 1b. For any given unit, there is an input voltage where the input bias current is zero (assuming no significant package or circuit layout leakage). In fact, with a rail-to-rail op amp you can often self-bias the input (figure 2) and the output will drift to a voltage equal to the zero input bias current point. It's an interesting experiment but not a particularly useful circuit.

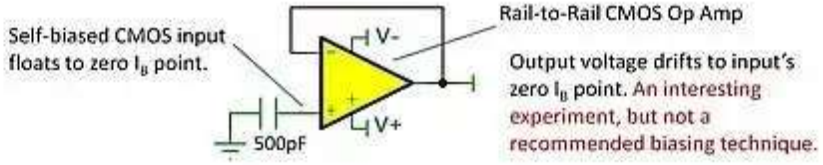


Figure 2.

The story can be different with JFET-input amplifiers such as the **OPA140 < http://www.datasheets.com/search/partdetail/opa140aid/texas-instruments>** . Here, the gate of the input transistor is a diode junction and its leakage current is often the dominant source of input bias current. The input gate junction is generally larger and therefore more leaky than the protection diodes. Thus, the input bias current is more often unidirectional. It can vary and depends on the amplifier.

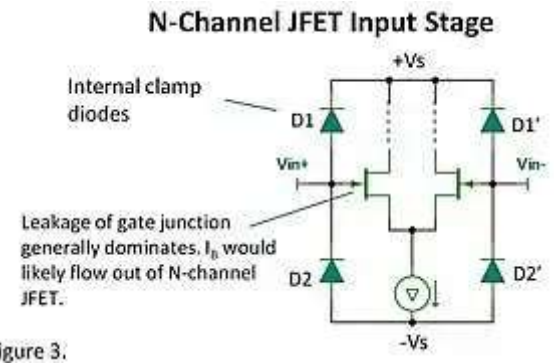
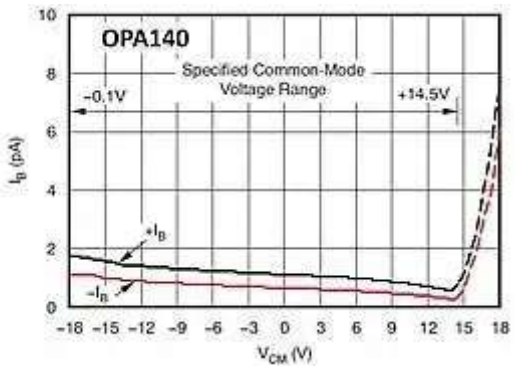


Figure 3.



So… what to conclude? If very low input bias current is important in your circuit, be aware. Look carefully at typical performance graphs to glean all available information. If you operate with input voltages that are near the positive or negative rails, you may have higher input bias current. This leads up to another important point—input bias current will increase significantly with temperature. More on temperature effects in a future blog.

This discussion applies to most common general-purpose CMOS and JFET amplifiers but there are special-purpose amplifiers designed for ultra low input bias current. They use creative protection circuitry unique pinouts to achieve I_B in the range of 3fA—three orders of magnitude lower than general purpose devices. Examples:

LMP7721 < http://www.datasheets.com/search/partdetail/lmp7721ma-slash-nopb/texas-instruments> — 3fA Input Bias Current CMOS Op amp

INA116 < http://www.datasheets.com/search/partdetail/ina116ua/texas-instruments> —Ultra-Low Input Bias Current **Instrumentation Amplifier < http://e2e.ti.com/support/amplifiers/precision-amplifiers/w/design-notes/1777.aspx>**

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dates

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There's another interesting thing about bipolar vs CMOS vs JFET op-amp bias currents. At ac 1kHz)and a non-inverting buffer application with large input voltages, then the input current to op-amp has a big component due to ac current flowing in t

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