Application Brief

How to Prevent Errors in Voltage Readings When Using Multiplexers with High Input Impedance Op-Amps

Kameron Hill

Multiplexers in Cost-Optimized Signal Processing Applications

To achieve cost-effective sensor data processing, system designers often use a bidirectional analog multiplexer with operational amplifiers (op-amps) to create an input interface. This combination allows one multiplexer to connect to multiple downstream signal paths, each with different gain configurations for the op-amps. This combination enhances data transmission efficiency and functionality from a single sensor.

A problem can occur when the input resistance of an op-amp, such as the TLV9004, is significantly greater than the off resistance of a multiplexer. If these compatibility issues are not considered during system design, voltage errors can arise on the multiplexer's unselected signal path. This can lead to incorrect voltage readings being transmitted downstream to various data processing devices, resulting in measurement errors in the application.

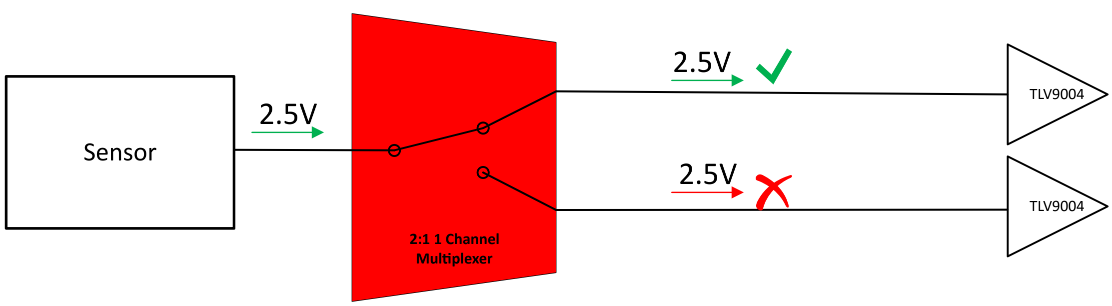

Figure 1. Example of Voltage Error on Unselected Signal Path of Multiplexer

How to Prevent Voltage Error on Unselected Signal Paths

To prevent voltage errors that may arise on the unselected signal path in this application, designers can implement a bleeder switch in combination with a pulldown resistor placed parallel to the operational amplifier (op-amp). This approach is effective because when the bleeder switch is closed, the pulldown resistor becomes parallel to the input resistance of the op-amp. This arrangement alters the resistance ratio between the off-resistance of the multiplexer and the op-amp load resistance. As a result, the off-resistance is greater than the load resistance, allowing more voltage to drop across the multiplexer. This reduces the voltage at the op-amp's input, effectively discharging the floating node or high impedance of the op-amp input. Ultimately, if a strong pulldown resistor is used, the voltage seen by the op-amp's input on the unselected signal path can be approximately 0V.

To implement this solution, the bleeder switch must connect when the signal path is unselected and disconnect when it is selected. This allows the system to transmit the correct voltage reading from the sensor to the op-amp through the selected multiplexer signal path. Figure 2 and Figure 3 show the implementation of the bleeder switch solution, while Figure 4 shows a system implementation of this solution. Furthermore, system designers can alternatively use a bleeder multiplexer to connect pulldown resistors in their application. Figure 5 illustrates how a multiplexer can be used to connect and disconnect multiple pulldown resistors.

To help designers understand the relationship between a multiplexer's off resistance and an op amp's input resistance, as well as to estimate the necessary bleeder resistor for their application, they should start by determining an acceptable voltage level for the op amp's input when the multiplexer signal path is unselected.

Once this voltage level is established, they can use the multiplexer's maximum off-leakage current along with the acceptable voltage level of the unselected signal path to estimate the required bleeder resistor.

For example, if the acceptable voltage on the unselected signal path is 0.2V and the maximum off-leakage current of the multiplexer is 1000nA, then by rearranging Ohm's Law (V/I = R), we can find that the bleeder resistor needs to be less than 200 kilohms.

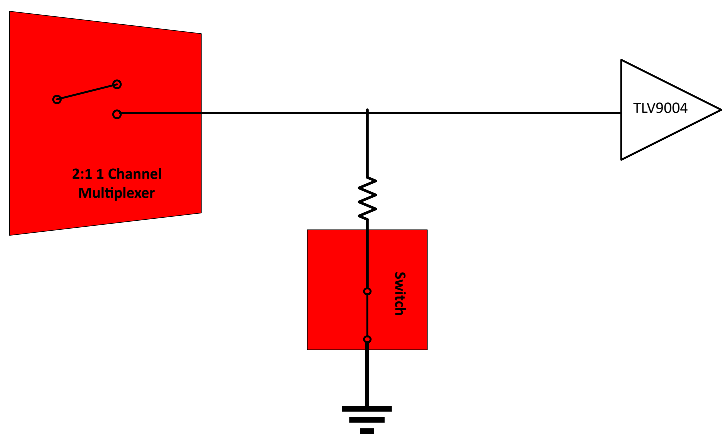

Figure 2. Bleeder Switch Activated on unselected signal path

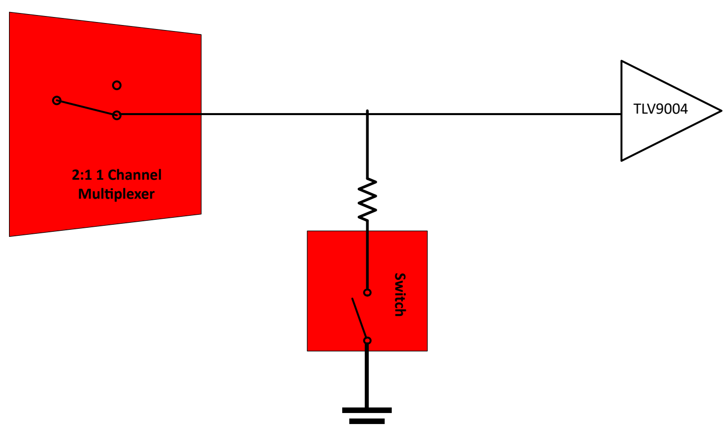

Figure 3. Bleeder Switch De-activated on selected signal path

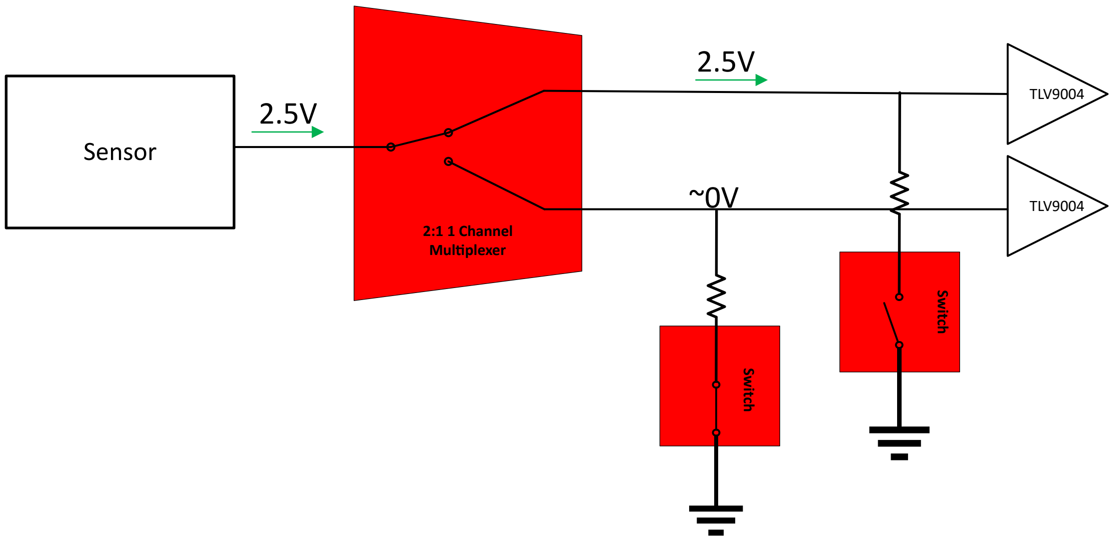

Figure 4. System Implementation of Bleeder Switch Solution

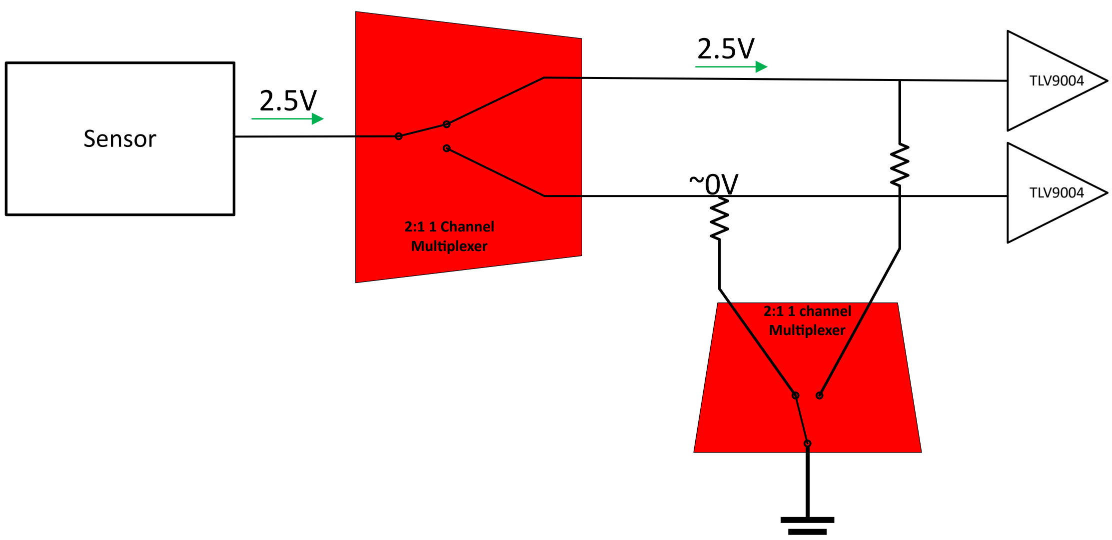

Figure 5. System Implementation of Bleeder Multiplexer Solution

Design Considerations

- The bleeder switch or multiplexer connected to the design must be rated for the same voltage and current specifications as the multiplexer connected to the sensor. This compatibility is crucial to prevent damage to the bleeder switch or multiplexer.
- Learn about multiplexer off resistance here.
- Learn about multiplexer parameters with TI Precision Labs Videos.
- Ask a question on our TI E2E™ Design Support Forum.

Table 1. Recommended Parts for Bleeder Switch/Multiplexers

Part Number	Supply Range (V)	Configuration	Channel Count	Control Logic
TS5A3166	1.65 to 5.5V	1:1(SPST) Switch	1	Active High
SN74LVC1G66	1.65 to 5.5V	1:1(SPST) Switch	1	Active High
CD74HC4066	2 to 10V	1:1(SPST) Switch	4	Active High
TS5A3167	1.65 to 5.5V	1:1(SPST) Switch	1	Active Low
TMUX1219	1.08 to 5.5V	2:1(SPDT) Multiplexer	1	Active High and Low
SN74LVC1G3157	1.65 to 5.5V	2:1(SPDT) Multiplexer	1	Active High and Low
TMUX4053	5 to 24V	2:1(SPDT) Multiplexer	3	Active High and Low

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