

Amplifier Disable Function Eliminates Need for Multiplexers in Multichannel Applications

By Charly El-Khoury

A *multiplexer* (mux) routes the signal from one of several inputs to a common output, allowing one device or resource—such as an ADC in a mixed-signal application or a display in a video application—to be shared, rather than dedicating a device to each input. Many applications use amplifiers to condition the signal before the multiplexer. In these cases, amplifiers with a disable function can be used to select the channel, eliminating the need for a multiplexer—and reducing cost, PCB area, and distortion. This article presents the challenges of using op amps with a disable function for channel selection and offers examples from ADI’s high-speed amplifier portfolio.

First, it is important to compare the *disable* function with the *power-down* function. When an amplifier is disabled, the power consumption drops, and the output goes into a high-impedance state, allowing multiple outputs to be tied together. This differs from the power-down function, which is only intended to save power.

When using op amps to select channels, the second thing to consider is the maximum voltage allowed between the amplifier inputs. This information is usually found in the Absolute Maximum Ratings on the data sheet, as shown in Figure 1. If the amplifier has back-to-back diodes between its inputs, the differential input voltage will be limited—even when the amplifier is disabled—to 0.7 V, 1.2 V, or more depending on the number of series-connected back-to-back diodes.

ABSOLUTE MAXIMUM RATINGS¹

Supply Voltage	12.6 V
Internal Power Dissipation ²	
PDIP Package (N)	1.3 W
SOIC Package (R)	0.9 W
Input Voltage (Common Mode)	$\pm V_S$
Differential Input Voltage	± 3.4 V
Output Short-Circuit Duration	Observe Power Derating Curves
Storage Temperature Range N, R	-65°C to $+125^{\circ}\text{C}$
Operating Temperature Range (A Grade) ...	-40°C to $+85^{\circ}\text{C}$
Lead Temperature Range (Soldering 10 sec)	300°C

Figure 1. AD8041 absolute maximum ratings.

Some amplifiers, such as the **AD8041**, do not have back-to-back diodes between their inputs, so they can handle differential input voltages of up to ± 3.4 V. When disabled, the amplifier output is in a high-impedance state. Configured for a gain of 2, two amplifiers can be connected to select one of two channels while operating on a single 5-V supply, as shown in Figure 2.

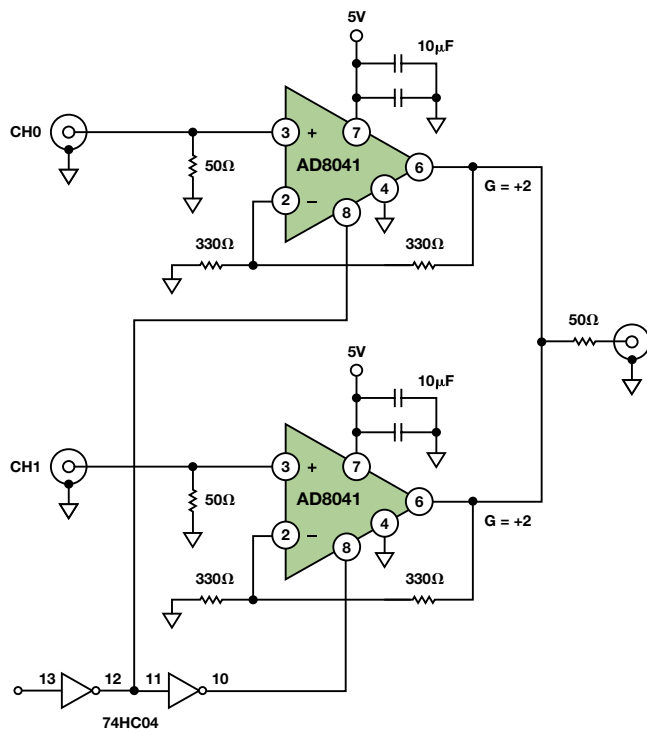


Figure 2. 2:1 multiplexer using two AD8041 op amps.

This is not true for all amplifiers with disable pins, however. To illustrate this, Table 1 shows some high-speed amplifiers with a disable function, along with their differential input voltage ratings, bandwidth, and minimum gain requirements.

Table 1. High-Speed Amplifiers with Disable Function

Part Number	# of Amps	Bandwidth (MHz)	Differential Input Voltage (V)	Minimum Stable Gain
AD8021	Single	490	± 0.8	1
AD8027	Single	190	± 1.8	1
AD8029	Single	125	± 1.8	1
AD8041	Single	160	± 3.4	1
AD8063	Single	320	± 6	1
AD8099	Single	440	± 1.8	2
ADA4853-1	Single	100	± 5	1
ADA4895-1	Single	236	± 0.7	10
ADA4897-1	Single	230	± 0.7	1
ADA4899-1	Single	535	± 1.2	1
AD8028	Dual	190	± 1.8	1
ADA4853-2	Dual	100	± 5	1
ADA4895-2	Dual	236	± 0.7	10
ADA4897-2	Dual	230	± 0.7	1
AD813	Triple	125	± 6	1
AD8013	Triple	230	± 6	1
AD8023	Triple	460	± 3	1
ADA4853-3	Triple	100	± 5	1

As an example, the [ADA4897-2](#) dual low-power op amp with individual disable pins will be used for both signal conditioning and channel selection, eliminating the need for a multiplexer. Figure 3 shows a simple schematic of two unity gain buffers configured as a 2:1 channel selector. Three scenarios will be analyzed: 1) two input sources, CH0 and CH1, have a 2.5-V dc level and a 0.5-V p-p ac signal; 2) same signals but with a 1-V dc offset between the two input sources; and 3) same dc level with a 1-V p-p ac signal. Due to the back-to-back diodes between the inverting and noninverting inputs of each amplifier, the differential input voltages should not exceed 0.7 V.

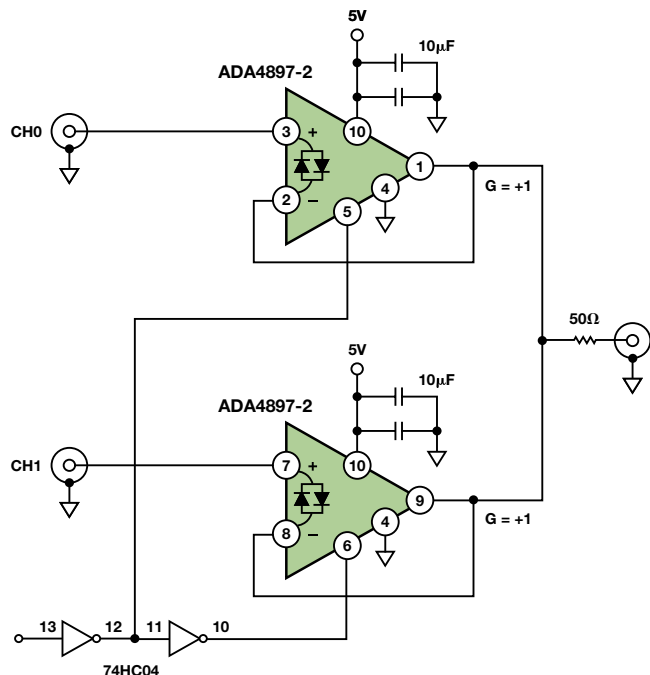


Figure 3. 2:1 multiplexer using the dual ADA4897-2.

When an amplifier is enabled, the feedback forces the inverting and noninverting inputs to be equal, but when the amplifier is disabled, the feedback loop is opened, and the inputs can drift apart. With back-to-back diodes between the two inputs, the amount they can drift apart is limited. In the case of the ADA4897-2, the inputs cannot drift apart by more than a diode drop (0.7 V), or the back-to-back diodes will turn on. To help illustrate this point, Figure 4 shows a simplified schematic of the circuit with one amplifier disabled.

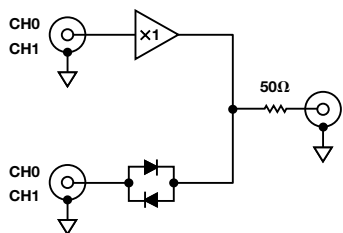


Figure 4. Simplified schematic of Figure 3 with one amplifier disabled.

Returning to our three scenarios, if the dc levels on CH0 and CH1 are equal, the maximum differential ac signal that can exist between the two input sources is 0.7 V before the diodes become forward-biased. The first scenario will work as expected because the maximum differential signal is only 0.5 V p-p. In the second scenario, the two input sources have a dc offset level greater than 0.7 V, so the circuit will not work. In the third scenario, the maximum differential signal could reach 1 V p-p when the two

input sources are 180 degrees out of phase. This will cause the back-to-back diodes to become forward-biased, so the circuit will not work under these conditions either. Using the AD8041 or other amplifier (from Table 1) with a large enough differential input voltage would be a better option for the last two scenarios.

If an amplifier with back-to-back diodes must be used due to cost or performance considerations, and adding an extra multiplexer is not an option, setting the amplifier for a gain greater than 1, or using feedback resistors in the unity-gain configuration, can make the problem less severe. The second option is only an issue with voltage feedback amplifiers, as they are not meant to use a feedback resistor for unity gain. If peaking is a problem, however, a capacitor, in parallel with the feedback resistor, can reduce the peaking and minimize the effects of the feedback resistor.

Figure 5 shows a simplified schematic of Figure 2, but using the ADA4897-2 instead of the AD8041. The amplifiers are configured for a gain of 2.

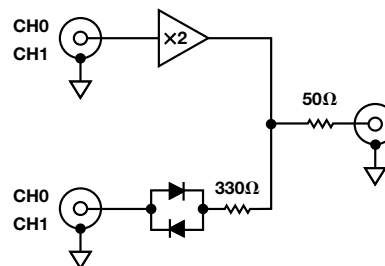


Figure 5. Simplified schematic of Figure 2 with ADA4897-2.

In this circuit, the feedback resistor limits the current that can flow through the back-to-back diodes. This keeps the diodes from becoming completely forward-biased and loading the circuit. If, for example, CH0 and CH1 were 1 V p-p, the maximum differential signal across the resistor (assuming 0.7-V diode drop) would be $1.5 \text{ V} - 0.7 \text{ V} = 0.8 \text{ V}$, which corresponds to a current of $0.8 \text{ V} / 330 \Omega = 2.4 \text{ mA}$. This worst case current is low enough compared to the load current, so the amplifier should be able to provide it while driving the rest of the circuit. Increasing the value of the feedback resistor will reduce the current, if necessary. Using a gain of 2 instead of unity gain (or using feedback resistors in unity gain, assuming the voltage feedback amplifier is stable in this configuration) allows double the ac input voltage. When using feedback and gain resistors, the offset dc voltage level between CH0 and CH1 can be canceled by adding a dc bias to the inverting input. In high-precision applications, it might be better to use amplifiers without back-to-back diodes because the diodes might distort the signal, even if they are not fully on.

In conclusion, using amplifiers with a disable function as channel selectors is possible as long as all input back-to-back diodes remain unsaturated. A unity-gain configuration is more limited than higher gains, where the gain and feedback resistors can be used to limit current flow through the back-to-back diodes and eliminate the dc bias. If unity gain is required, resistors can be used in the feedback loop as long as the amplifier is stable in this configuration. Finally, keep in mind that back-to-back diodes can cause distortion, so amplifiers without back-to-back diodes might be a better choice for high-precision applications.

Author

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