Using ALD Low-Power, Low-Voltage Precision Voltage Clamps

Systems and circuits that are susceptible to damage in over-voltage conditions benefit from voltage clamps to ensure that voltages remain below a critical limit. But because this is a protection measure, rather than a functional portion of the circuit, the clamp should have a minimal impact on the system when not actively clamping.

The ideal voltage-clamp should have the following characteristics:

1. It would draw little to no power when the voltage is below the clamping threshold.
2. The current would increase to infinity in a step function when the voltage hits the clamping threshold.
3. The clamp voltage would be identical on each circuit.
4. The clamp voltage would be extremely precise.
5. The clamp voltage would be available in lower voltage ranges less than 5 V.

The ALD clamping solution offers most applications most of these features.

Zener diodes have traditionally served as voltage clamps for many decades. They have approximated the requirement for a step function at the clamping threshold well enough to support historical applications. But, in modern low-power circuits, they can draw enough current to be noticeable or even dominate. A scan of precision Zener diodes shows examples that draws as much as 50 µA or even 20 mA. This will be a significant issue for circuits measuring their current in nanoamperes.

Precision Zener diodes also have around ±2% precision on their threshold voltages. That is more precise than non-precision Zener diodes, but it can still be higher variation than sensitive circuits require. Examples of circuits that require low power and high precision include wireless transmitters, battery management, supercapacitors, energy-harvesting circuits, and sensors – especially those used in the industrial internet of things (IIoT), where the behavior of dangerous equipment may be at stake.

Low-Power Precision Clamps

The ALD OVP low-power precision voltage-clamping devices provide both the low power and the clamping voltage precision that sensitive modern systems require. Leakage current is typically in the range of 400 pA, with a worst-case value of 4 nA – less than 1/1000th the leakage of some precision Zener diodes. The voltage clamping threshold has a precision of ±0.8% (for example, ±0.02 V on a 2.5-V clamp), a range that is 60% tighter than that of precision Zener diodes.

The sharpness of the turn-on current, which would ideally be a step function, is illustrated by the following I/V curve for the ALD910025S in which two clamps have been stacked. Each having a nominal 2.5-V clamp threshold.

Low-Voltage Precision Clamps

The ALD OVP low-power precision voltage-clamping devices also provide excellent low-voltage control in applications where the clamping voltage is at or less than 5 V, to as low as 1.6 V (SABMBOVP216). Such low clamping voltages are out of range for most Zener diodes. With a Zener diode, a lower clamp voltage necessitates further voltage reduction techniques such as a resistor divider, amplifier buffering circuits, and voltage regulator circuits that add to the complexity, the power budget, and cost. The ALD OVP clamps can handle the lower voltages with no additional components.

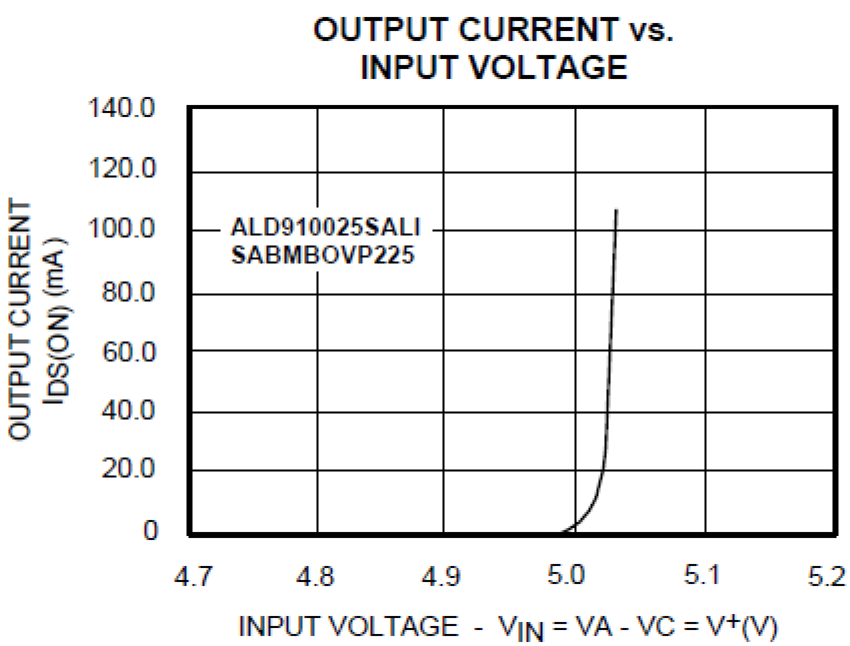
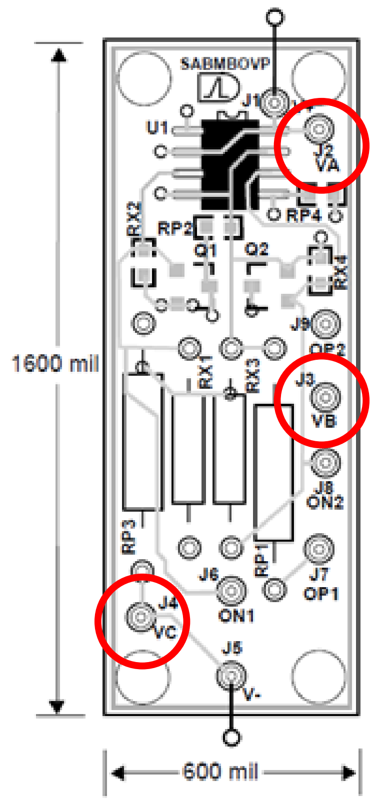


Figure 1. Clamping current as a function of input voltage for two stacked 2.5-V clamps. There is a sharp turn-on at 5 V.

Connecting and Stacking Voltage Clamps

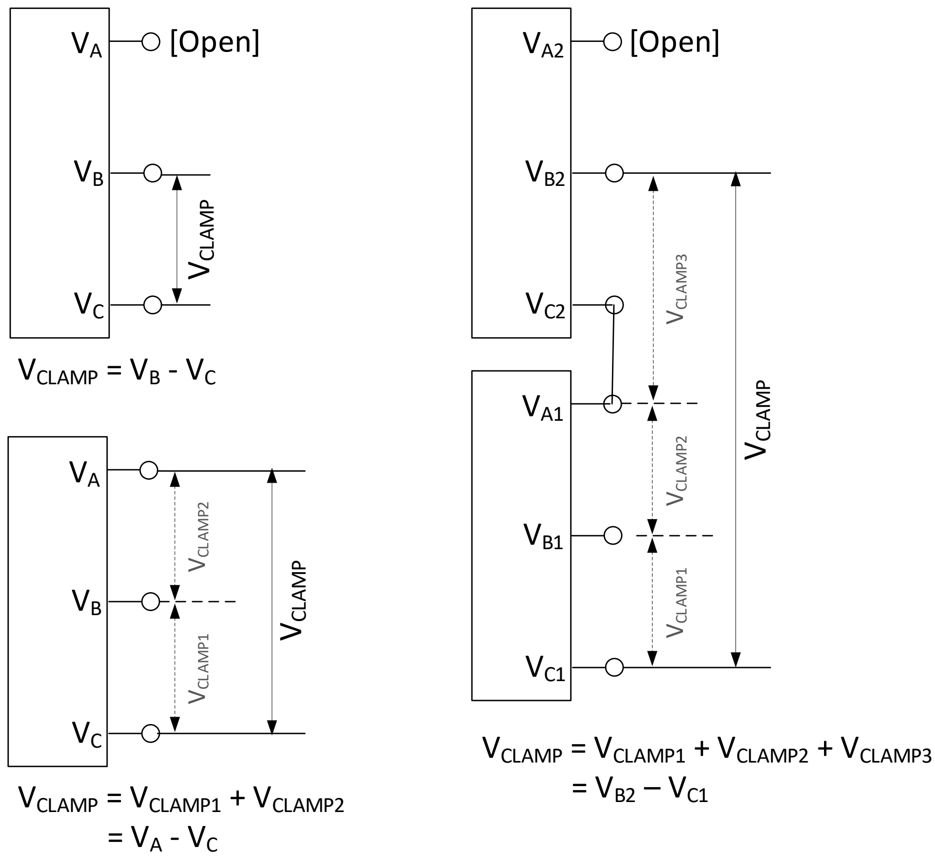
The following drawing illustrates the pinout of the ALD clamps. Most of the pins are left open; only pins V_A, V_B, and V_C are connected in this application.



* Magnified, not to scale

Each device provides two identical clamp voltages. One is between V_B and V_C; the other is between V_A and V_B. These can be used as independent clamps as long as the V_B level of the $V_{A\text{-}B}$ clamp is the same as the V_B level of the $V_{B\text{-}C}$ clamp.

These clamp levels may also be stacked to provide double the basic clamp threshold. Also, multiple devices can be stacked to give yet higher thresholds. While the two clamp voltages on a single device will be identical, different devices with different clamp voltages can be included in the stack. The following illustrations indicate the required connections for stacking clamp voltages.



For the top left circuit, a single clamp is used. In this situation, the clamp must be between V_B and V_C; V_A is left open. For the circuit below it, the basic clamp level is doubled by stacking V_{CLAMP1} and V_{CLAMP2}.

The righthand circuit illustrates the use of a second device for a three-level clamp. The V_{C1} of the top device is connected to the V_{A1} of the bottom device. Note that the top and bottom devices could have different thresholds, meaning that V_{CLAMP3} might be different from V_{CLAMP1} and V_{CLAMP2}. In this case, V_{A2} is left open. It could be connected for a four-level clamp.

There is no limit to the number of devices that can be stacked as long as the voltage range on any individual device does not exceed the absolute maximum rating.

For more information on these devices, consult the SABMBOVP datasheet at aldinc.com.