Application Note

Extend LM5067 Applications With an External Auxiliary Source

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ABSTRACT

In everyday life, there are many hot-swap scenarios. One of the hazards of hot-swap is that the transient rush currents and voltages generated by hot-swap can damage the post-stage circuitry. Hot-swap protection chips limit the transient power and transient current generated during hot-swap to protect the post-stage circuit. Hot-swap protection chips sometimes need to adapt to large dynamic range voltage swing, which can cause overstress on certain parameters of the chip during use. This paper proposes a method to add an auxiliary source. Theory and experimental verification can be used to extend the dynamic voltage operating range of this chip.

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1 Introduction

In real life, we often have such a scenario, when we connect the computer through the USB or HDMI interface to connect external devices, hard disks or monitors, we do not cut off the power supply of the PC, the external device is directly unplugged or plugged in, which is called hot-swap with power for this type of use scenario. Hot-swap allows users to remove and replace damaged hard drives, power supplies, or boards without shutting down the system or cutting off the power supply, thereby improving the system's timely disaster recovery ability, scalability, and flexibility. However, in the process of hot-swap, transient peak current and voltage occurrence is likely, if not protected, this causes the rear circuit to be damaged by the impact of transient high power. As shown in Figure 1-1, this is a typical application scenario for hot-swappable protection chips.

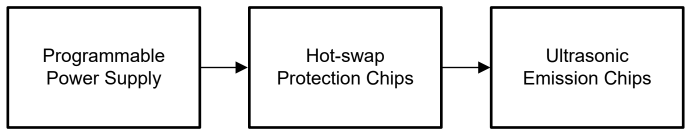

Figure 1-1. Ultrasonic Emission Link

Because the ultrasonic equipment needs to select different probes according to different detection objects, there are hot-swap scenarios, in this application, to maintain the stability and reliability of the entire ultrasonic system in the application process, hot-swap protection chips are necessary. LM5067 is a negative voltage hot-swap protection chip launched by TI in 2020. The voltage operating range of LM5067 is -9V to -80V, while the negative voltage range of conventional ultrasonic emission systems is typically -9V to -64V. In terms of specifications, LM5067 meets the current application scenario. The internal block diagram of the L M5067 is shown in Figure 1-2, which can set the UVLO (Undervoltage lockout) and OVLO (Overvoltage lockout) to protect the post stage circuit. The specification of the LM5067 indicates the absolute maximum voltage value of the UVLO pin can not exceed VEE+17V. If exceeded, permanent damage can occur.

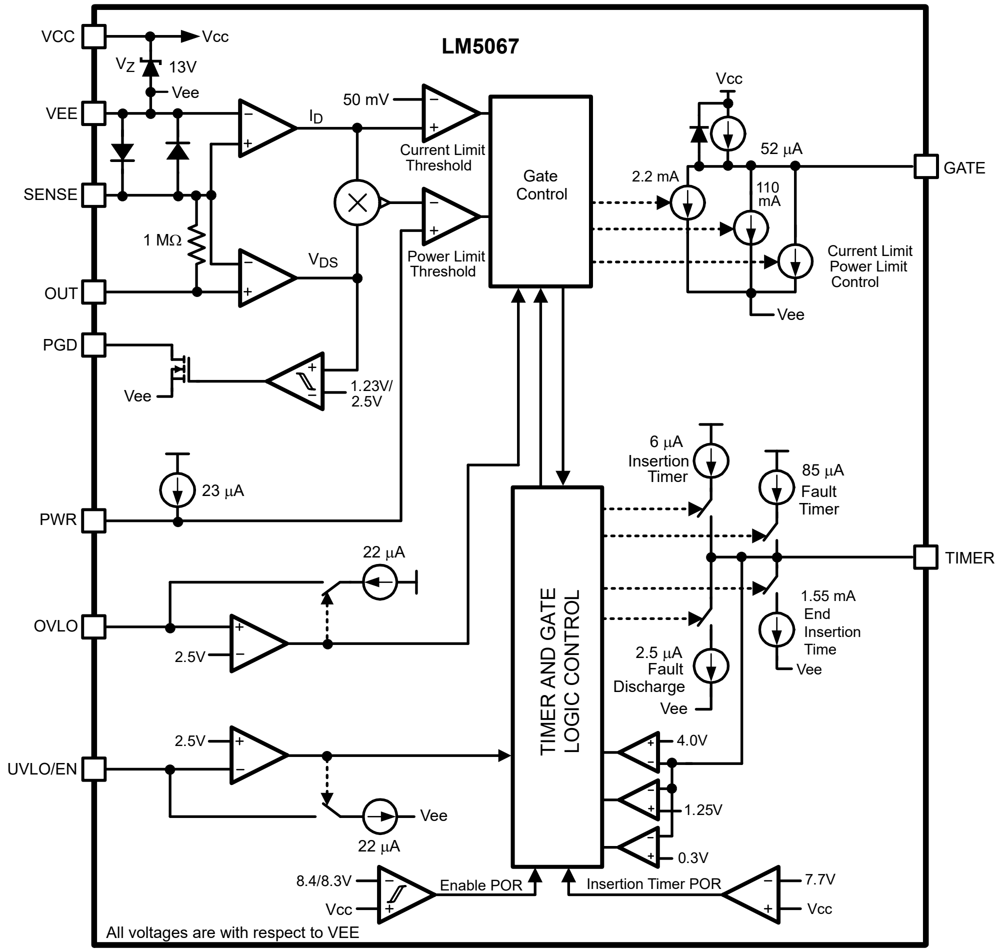

Figure 1-2. LM5067 System Block Diagram

In a practical application, the system needs to have a dynamic change in the operating voltage, ranging from -9V to -64V. The LM5067 can be set with the voltage thresholds of UVLO and OVLO using the external resistor divider ratio as shown in Figure 1-3. UVLO pin voltage can be expressed as Equation 1.

$$UVLO = \frac{(R2 + R3)}{(R2 + R3 + R1)} \times (VCC - VEE) \tag{1}$$

When VCC = 0V, VEE = -9V, the resistor-to-voltage ratio must be at least 9:2.5 to meet the voltage of the UVLO pin minimum voltage greater than 2.5V, according to the calculation, when VCC=0V, VEE=-64V, the voltage of the UVLO pin can reach 17.7V, which is beyond the normal voltage working range of the chip. To solve this problem, we can change the voltage of the UVLO pin through the external circuit.

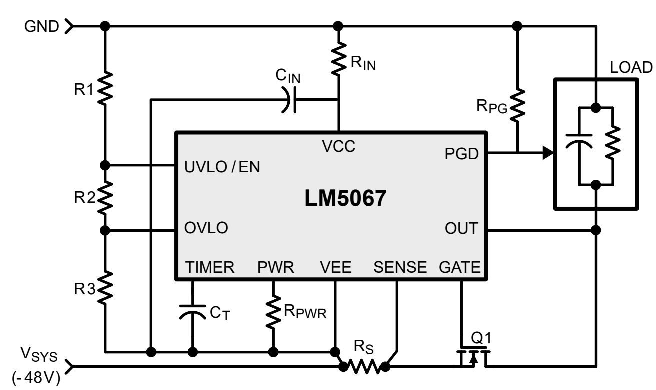

Figure 1-3. Typical Application of LM5067

2 The External Auxiliary Power Supply and Op Amp Follows and Changes the UVLO Swing Amplitude of LM5067

As shown in Figure 2-1, Figure 2-2, and Figure 2-3, the external auxiliary power supply can use a regulated diode, an external DAC, LDO, and other available power supplies and follow through the op amp, you can output an adjustable power supply VS, and the adjustable power supply VS is added to the voltage divider resistor. The voltage setpoint of the UVLO Pin can be expressed as Equation 2.

$$UVLO = \frac{(R2 + R3)}{(R2 + R3 + R1)} \times \left(VS - VEE\right) \tag{2}$$

For the LM5067 to work properly, set the LM5067 to 2.5V. $UVLO_{MIN}$ when the voltage dynamic range of VS-VEE is R. The voltage swing range of UVLO Pin can be expressed as Equation 3.

$$UVLO_{MAX} = \frac{VS + R}{VS + 0} \times UVLO_{MIN} \ (UVLO_{MIN} = 2.5V) \tag{3}$$

Taking VS as the independent variable, the derivative of Equation 3 can be obtained and expressed as Equation 4.

$$\frac{d_{UVLO_{MAX}}}{d_{vs}} = \frac{-R}{(vs)^2} \times UVLO_{MIN} < 0, \ Monotonically\ decreasing \tag{4}$$

Therefore, if the resistor-to-voltage ratio is a fixed value, the maximum voltage of the UVLO pin can be reduced by increasing the VS.

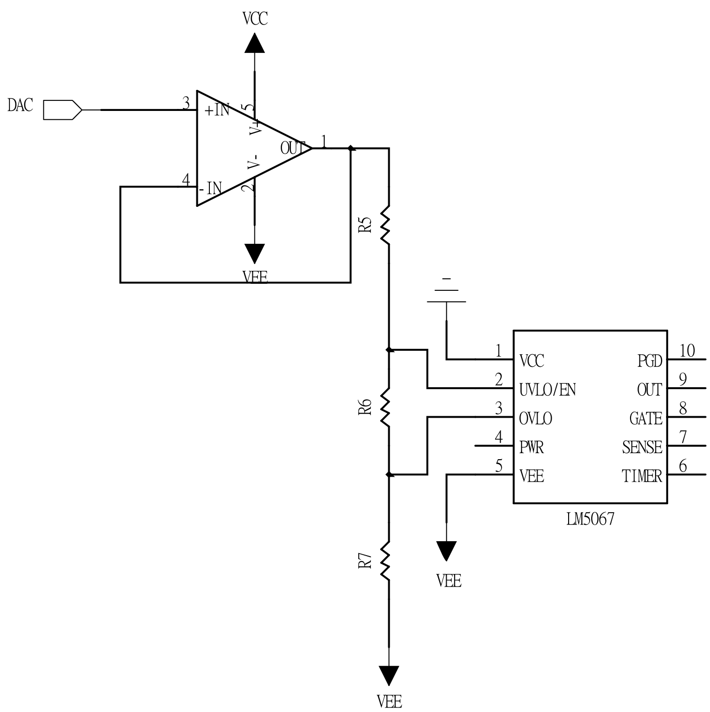

Figure 2-1. Set LM5067 UVLO With External DAC

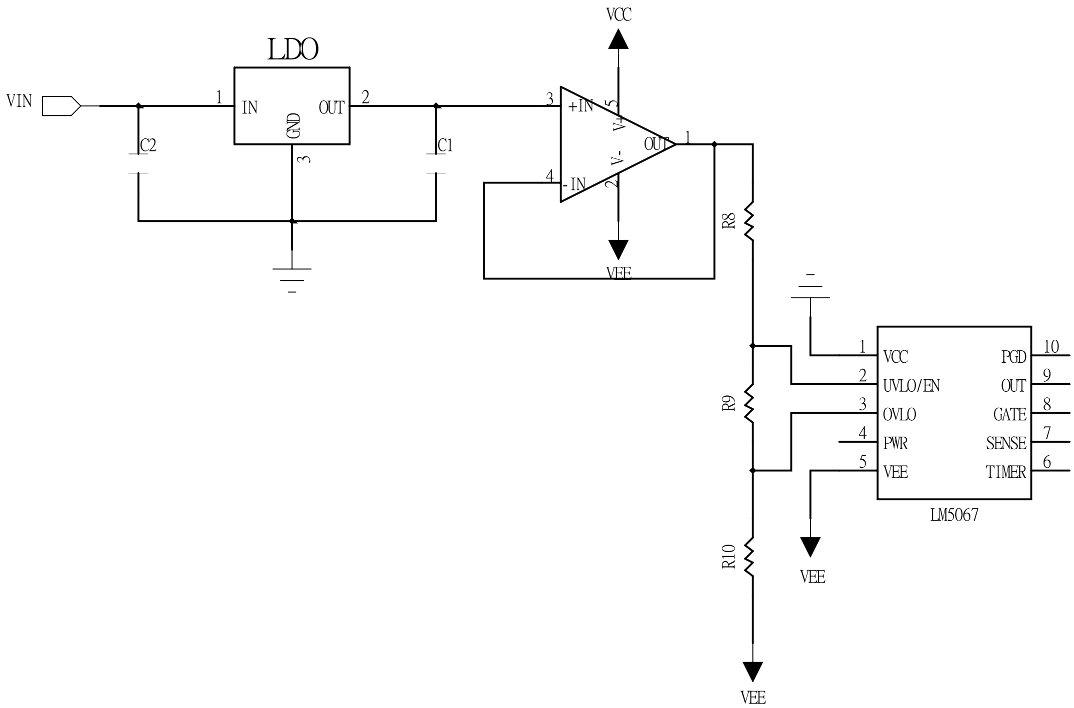

Figure 2-2. Set the LM5067 UVLO With External LDO

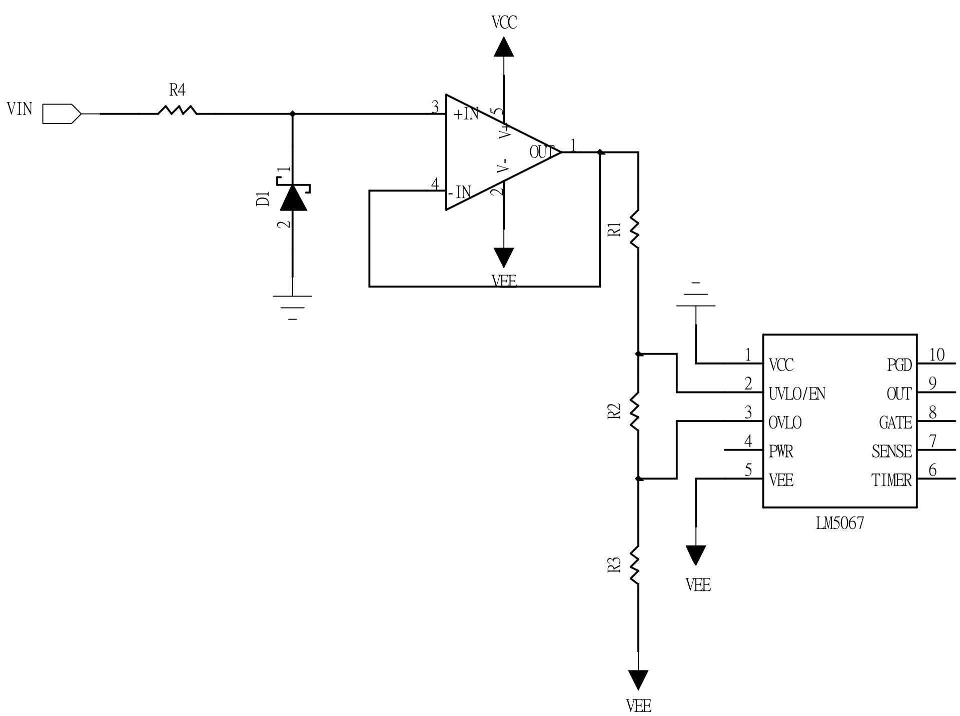

Figure 2-3. Set the LM5067 UVLO With External Zener Diode

3 Testing and Verification

When the dynamic variation range of VS-VEE is -9V to -63.5V, the voltage swing of UVLO Pin can be expressed as Equation 5.

$$UVLO_{MAX} = \frac{VS + 63.5}{VS + 9.0} \times UVLO_{MIN} \qquad (UVLO_{MIN} = 2.5V) \tag{5}$$

When VS = 5V, the theoretical values of the $UVLO_{MAX}$ is 12.39V.

$$UVLO_{MAX} = 12.39V < 17V \tag{6}$$

The actual test conditions are shown in Figure 3-1, and the setting is VS = 4.9V and VEE = 63.5V.

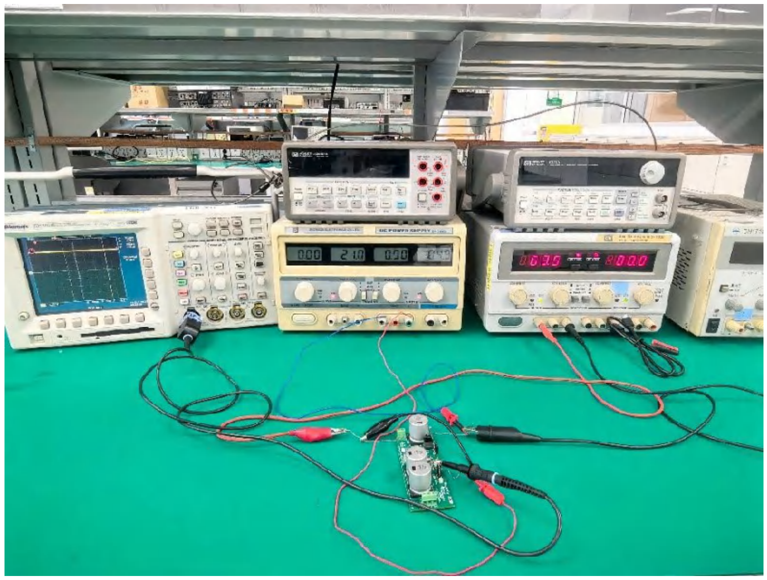

Figure 3-1. Actual Test Conditions

The test results are shown in Figure 3-2, and the measured UVLO is 12.3V, which is in line with the theoretical expectation.

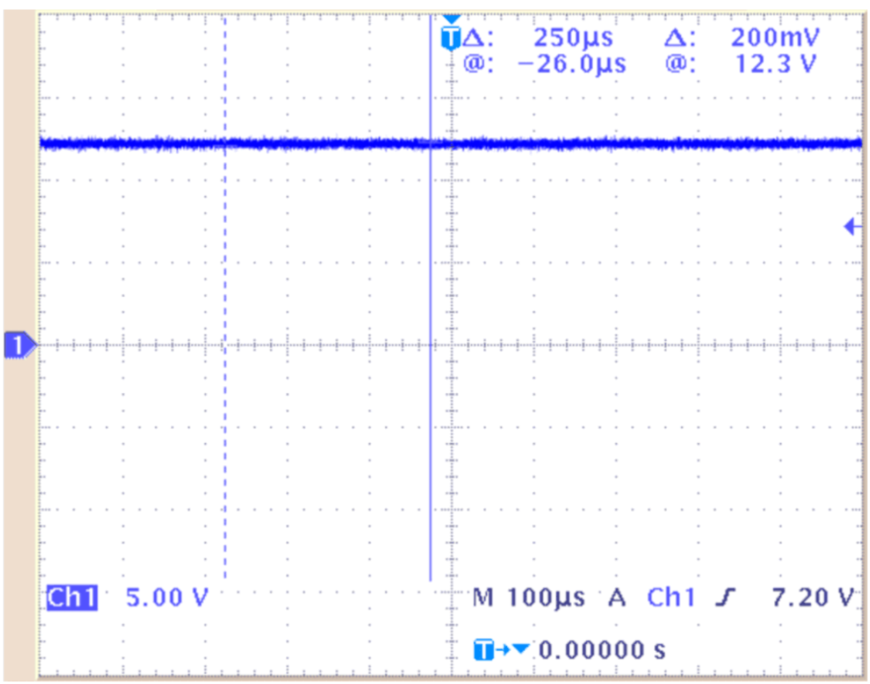

Figure 3-2. Measured Voltage at UVLO Pin

According to this method, the LM5067 can be made to work normally in a larger dynamic voltage range by applying an external power supply VS, which solves the problem of the LM5067 under the traditional single negative power supply, eliminates the limit of the dynamic output voltage range of the chip caused by UVLO pin voltage limit. For further protection of the UVLO Pin pin, A TVS or Zener diode can be added between VEE pin and VIN pin for voltage clamping.

4 Summary

According to this method, the LM5067 can be made to work normally in a larger dynamic voltage range by applying an external power supply VS, which solves the problem of the LM5067 under the traditional single negative power supply, eliminates the limit of the dynamic output voltage range of the chip caused by UVLO pin voltage limit. For further protection of the UVLO Pin pin, A TVS or Zener diode can be added between VEE pin and VIN pin for voltage clamping.

5 References

- Texas Instruments, *LM5067 Negative Hot Swap / Inrush Current Controller with Power Limiting* data sheet.
- Texas Instruments, *Basics of Power Switches* application report.

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