Control Hot-Swapping on Negative-Voltage Supplies

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Readily available positive-voltage controllers can be configured for hot-swapping either dual positive and negative supplies, or a single negative supply.

In addition to the usual array of positive-voltage supplies, many systems requiring hot-plug into a live backplane need at least a single –5-V or –5.2-V supply. There are numerous positive low-voltage hot-swap controllers for use in these applications; however, negative low-voltage controllers are rare to nearly nonexistent. Since the need for a low-negative-voltage hot-swap circuit typically arises when a low-positive-voltage hot-swap circuit is also in use, it is useful to create the negative-voltage circuit with the aid of a positive supply voltage.

The implementation of hot-swap control on dual +5-V/–5.2-V supplies can be accomplished with two circuits presented here. One employs a two-chip design using separate controllers for each channel, while the other uses a single controller IC for both channels. A third single-chip design is also presented for performing hot-swap on a single –5.2-V supply. All three circuits provide the functions of plug-in hot-swap with startup delay and controlled inrush current, but only one circuit includes an overload-detection and circuit-breaker function.

The two-chip solution shown in Fig. 1 allows independent circuit-breaker action on both negative- and positive-voltage channels. The two single-chip circuits shown in Figs. 2 and 3 provide startup inrush-current control, but neither provides current-limiting or circuit-breaker functions for the negative-voltage channel.

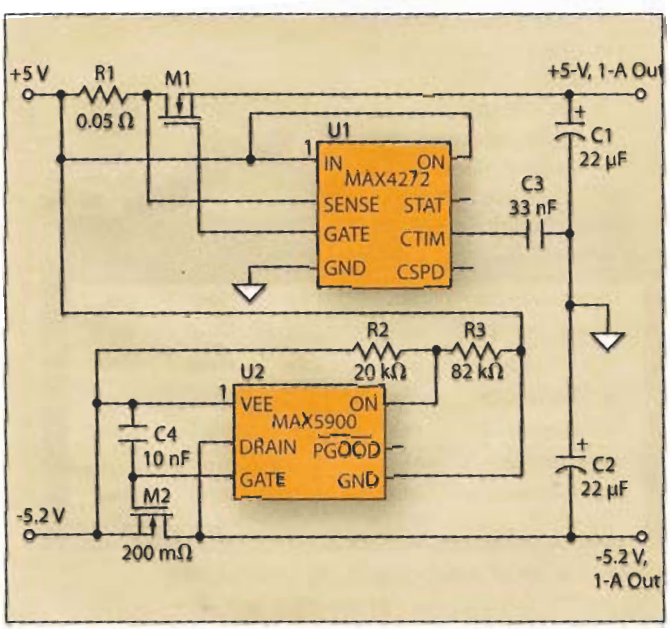

Fig. 1. *A two-chip approach to providing hot-swap control on positive and negative low-voltage supplies provides overload fault detection on both channels.*

Two-Chip Solution

The Fig. 1 circuit provides full hot-swap control, including current-limit and circuit-breaker functions for both a +5-V channel and a –5.2-V channel. The circuit uses a MAX4272 low-positive-voltage controller for the +5-V channel. No low-negative-voltage hot-swap controllers are available, so the circuit uses a MAX5900 high-negative-voltage controller for the –5.2-V channel.

With the MAX5900's normal ground connection referenced to the +5-V supply, the resultant +10.2-V differential supply allows the MAX5900 to operate within its –9-V to –100-V operating range. The MAX5900 is selected specifically because of its low –9-V minimum operating supply voltage. The MAX4272 is but one of many positive low-voltage controllers that could be used, but was selected because of its feature set in an eight-pin package.

Each channel is set for overload fault shutdown at approximately 1 A with auto restart action after a fault condition. The MAX5900 uses the M2 MOSFET's $R_{DS_{ON}}$ as the current-sense resistor, and the V_{SENSE} trip point is 200 mV. Selecting M2 for $R_{DS_{ON}} = 0.2\ \Omega$ allows an approximate 1-A overload trip point.

Refer to the individual data sheets for delay and timing information.

One-Chip Solution

The Fig. 2 circuit provides current-limited hot-swap startup control on both channels, but includes current-limit and circuit-breaker functions for only the +5-V channel. This one-chip solution employs a single two-channel MAX5904 controller to control both the +5-V and the –5.2-V channels. The MAX5904 normally controls two positive-voltage channels; however, it is possible to control one positive- and one negative-voltage channel with the circuit as shown. The MAX5904 is selected because of the dual-channel capability and because of the few external components required.

With the following configuration, the MAX5904 treats the +5-V channel as a +10.2-V circuit with full circuit-breaker function, and it treats the –5.2-V channel as if it were a +5.2-V circuit:

- Connect the MAX5904's GND pin to –5.2 V
- Connect the IN1 and SENSE1 pins to ground
- Connect the IN2 pin to +5 V.

When the MAX5904 is in off mode, both gates are pulled down to –5.2 V. In on mode, the GATE2 drive is 5.4 V above V_{IN2}, and the GATE1 drive is 5.4 V above V_{IN1}. Thus, normal inrush-current-limited turn-on functionality is provided for both the +5-V and the –5.2-V channels. No circuit-breaker action is available for the negative-voltage channel when used in this way; therefore, a fuse is provided to protect the negative supply circuit.

A fault on the negative channel will not be recognized by the MAX5904, but a fault on the +5-V channel will shut down both channels. Both channels will restart after an auto retry delay time. The ON pin may be brought out for logic control of the on/off function, but a simple level shifter is required because the MAX5904 is referenced to –5.2 V instead of GND.

Single-Channel Solution

The –5.2-V, single-channel hot-swap Fig. 3 circuit provides full startup control using a MAX4272 low-positive-voltage hot-swap controller. The MAX4272's GND pin is connected to the –5.2-V supply, while the IN and SENSE pins are connected to circuit ground. The MAX4272 then operates as if it were in a +5.2-V circuit except that no sense resistor is in the circuit, thus no overload circuit-breaker action is provided. The MAX4272 is but one of several suitable controllers that may have been selected, but was chosen because relatively few external components are required.

The MAX4272's ON pin may be connected directly to circuit ground, and the circuit will start 150 ms after the –5.2-V supply reaches –2.4 V. Alternatively, resistors R1 and R2 may be included in the circuit to set the turn-on voltage closer to 5 V. Adjust the R1/(R1+R2) voltage-divider ratio so that the ON pin rises 0.6 V above the negative-voltage supply at the desired supply turn-on voltage.

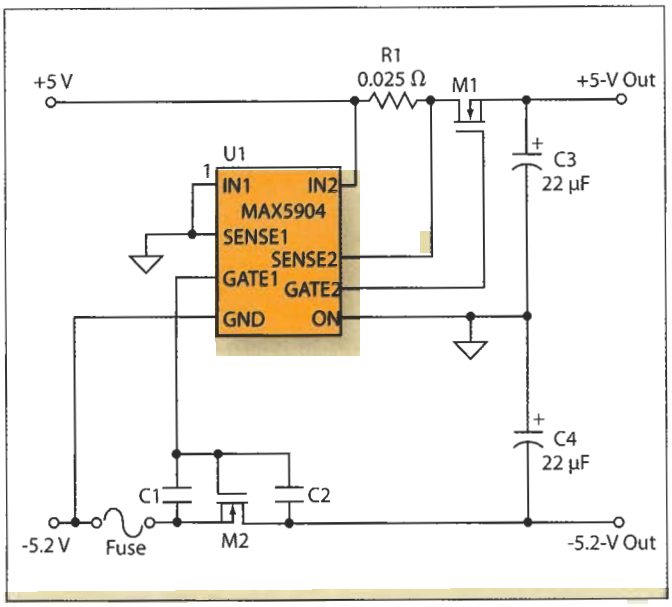

Fig. 2. *A single-chip solution provides inrush-current-limited turn-on functionality to positive and negative supplies, but without the circuit-breaker function on the –5.2-V channel.*

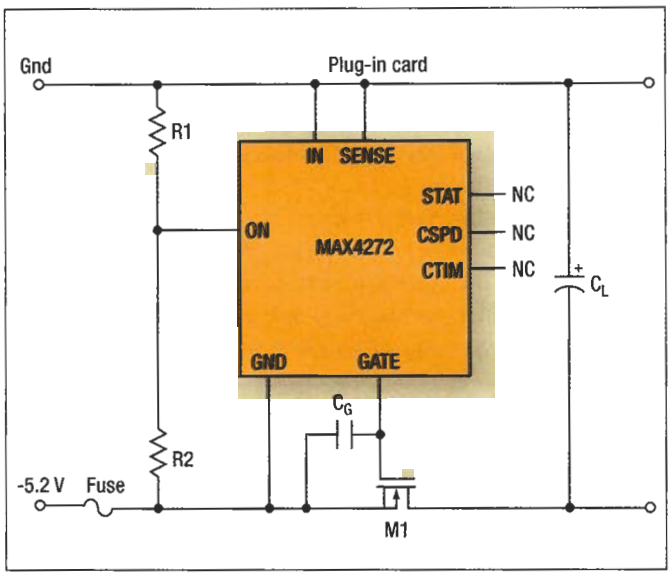

Fig. 3. *A single-chip design provides hot-swap control without circuit-breaker function on a single, negative supply, while also allowing for adjustment of turn-on voltage.*

There is no internal current limiting at startup, so C_G has been included to slow the gate voltage rate of rise at turn-on. As the internal gate drive is set to approximately 100 µA, the load capacitor will charge at a rate described by the following equation:

$$I_{C_{LOAD}} = 0.1\frac{C_{LOAD}}{C_{GATE}}(\text{mA}), \text{ where } C_{GATE} = C_G + c_{gs}(\text{of M1}).$$

As no current-limiting shutdown function is supplied for the Fig. 3 circuit, it may be desirable to include a fuse in series with the –5.2-V supply input terminal as is shown in Fig. 2. **PETech**