Monitoring and Controlling Negative Power Supplies with Power Manager Devices

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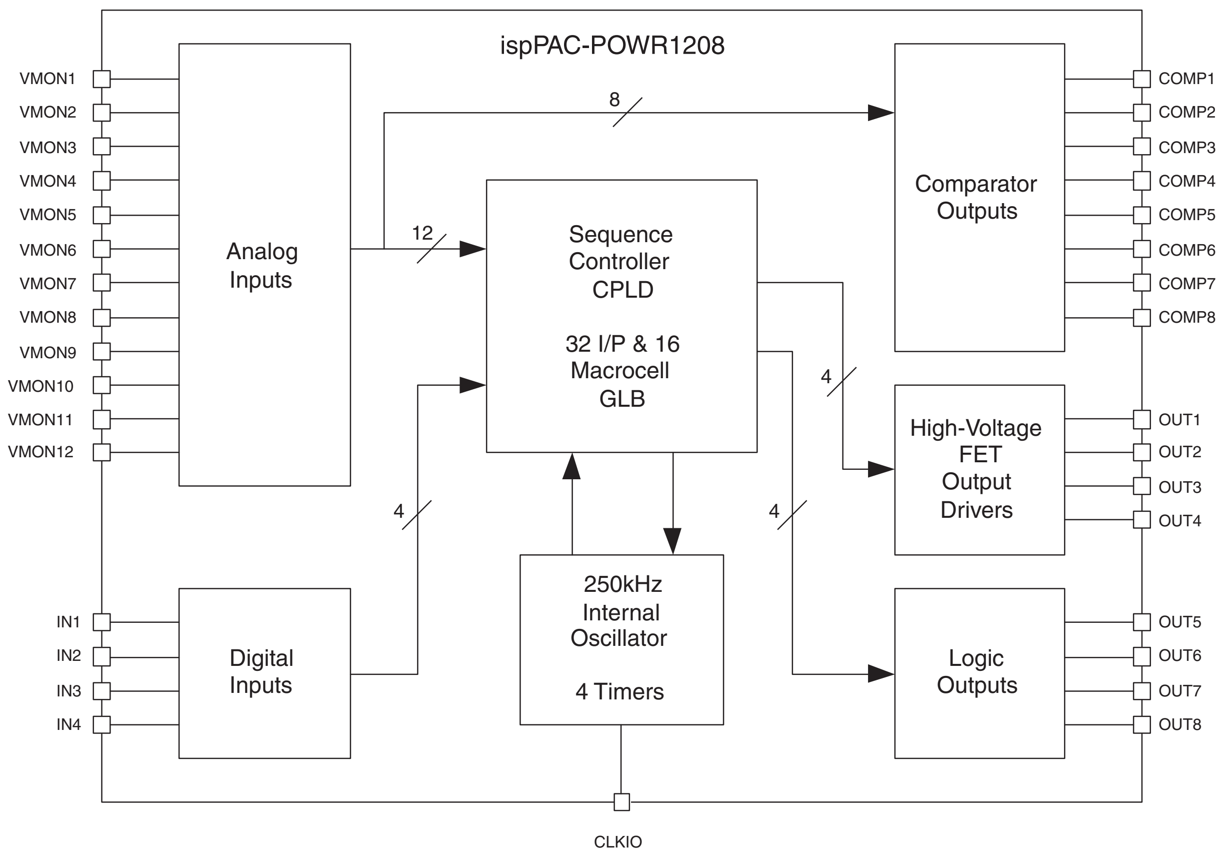
Introduction

Lattice Semiconductor's ispPAC®-POWR1208 and ispPAC-POWR604 both provide a single-chip solution for monitoring, sequencing and controlling on-board power supply systems. These devices incorporate both in-system programmable logic as well as analog circuits to perform the majority of functions required to implement a power supply sequencing and monitoring system. Figure 12-1 shows the top-level organization of the ispPAC-POWR1208.

Figure 12-1. ispPAC-POWR1208 Organization



The ispPAC-POWR1208 provides analog voltage monitoring functions for up to 12 external points. The analog monitor inputs may accept signals from 0 to 6V without the addition of external protection circuitry. Each of the 12 comparator trip points may be set independently over a range covering 1.03V to 5.74V, with 192 available values. The ispPAC-POWR604 offers similar capabilities, except that it supports six analog monitor inputs.

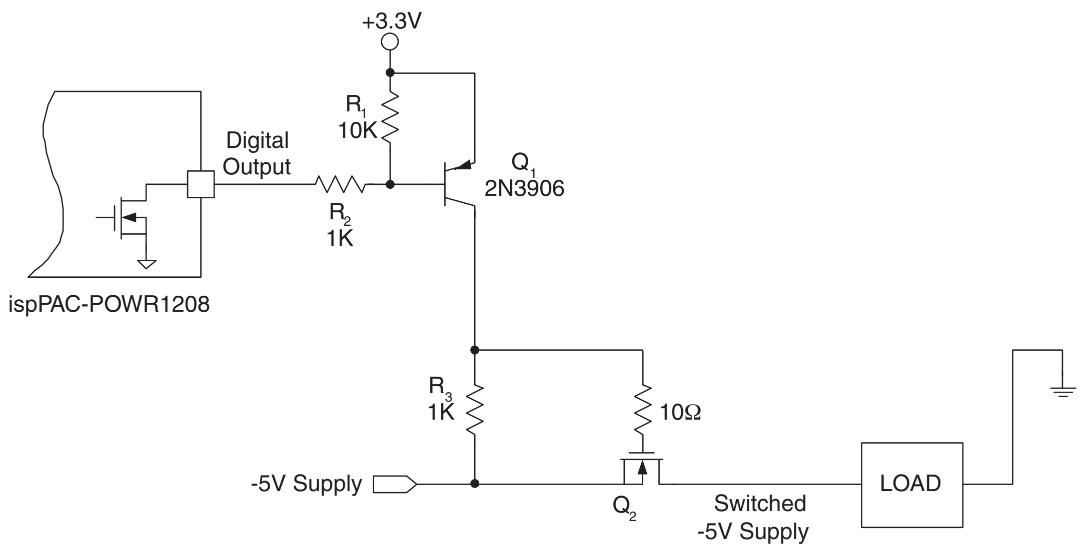
The ispPAC-POWR1208 operates from a single positive power supply ranging from 2.25V to 5.5V and provides direct glue-less support for both monitoring positive voltage signals and switching positive supply rails using n-channel power MOSFETs. In some board-level power systems, however, there may be a need for monitoring and controlling negative-voltage power supplies. In many cases, both the ispPAC-POWR1208 and ispPAC-POWR604 can provide monitor and control functions for negative-voltage systems with the addition of a few inexpensive discrete components. This application note presents some simple interface techniques which may be used to allow the ispPAC-POWR1208 to both monitor and control negative power systems. Although for the sake of simplicity, this application note refers to the ispPAC-POWR1208, all of the techniques presented here are also equally applicable for use with the ispPAC-POWR604.

Switching Negative Power Supplies

The ispPAC-POWR1208 incorporates high-voltage FET drivers which make it very simple for the ispPAC-POWR1208 to switch positive power supply rails through discrete power MOSFETs. Switching a negative power supply rail, however, requires that negative gate voltages be developed to switch the power MOSFET. While the ispPAC-POWR1208 can't directly provide negative gate-control signals, several simple interface circuits can be implemented that will allow it to control a power MOSFET switching a negative supply rail.

One such interface circuit is shown in Figure 12-2. This circuit uses a discrete transistor (Q_1) to perform the positive-to-negative level conversion needed to control the MOSFET (Q_2).

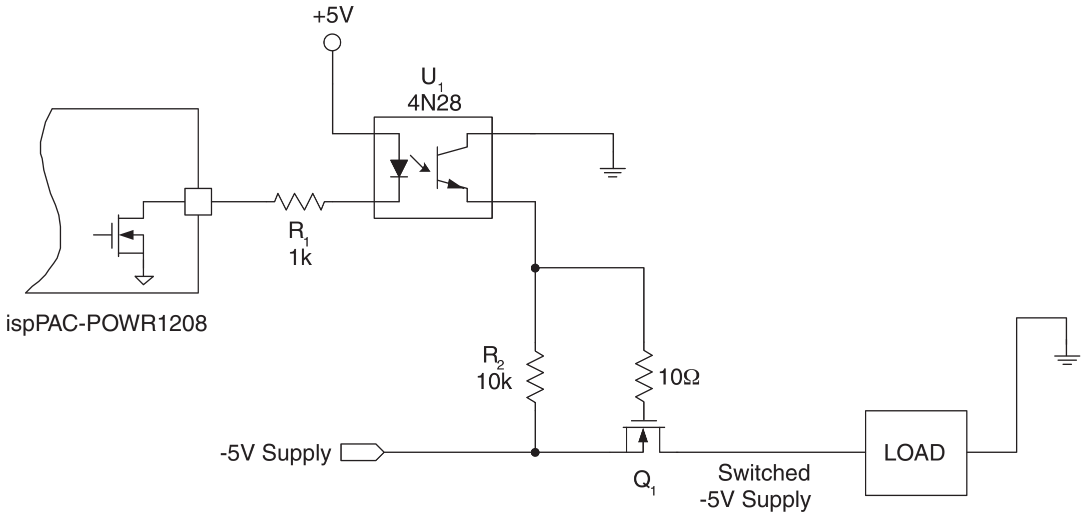
Figure 12-2. Transistor Interface for Controlling Negative Supplies



In this circuit, when the ispPAC-POWR1208's output goes LOW (the output transistor turns ON), it switches on PNP transistor Q_1. Current flows out of Q_1's collector and develops a voltage across R_3, which then turns on n-channel MOSFET Q_2. A relatively low value of R_3 is used to assure that the MOSFET's gate discharges quickly when the circuit is to be turned off. Note that this circuit does not provide the 'soft-start' capabilities provided by the ispPAC-POWR1208's high-voltage output drivers, and will turn on the load very quickly in response to a LOW.

Another way of translating from a positive control signal to a negative control signal is by using an optocoupler (U_1), as is shown in Figure 12-3. In this circuit, when the ispPAC-POWR1208's output goes low, it turns on the optocoupler's internal LED, which switches on its output transistor. This then turns on the MOSFET (Q_1). Because the optocoupler does not provide anywhere near as much current gain (1 vs. 100+) as the bipolar transistor used in the circuit of Figure 12-2, a larger gate-to-source resistor (R_2) must be used with the MOSFET. This has the effect of increasing the MOSFET's turn-off time.

Figure 12-3. Optocoupler Interface for Controlling Negative Supplies

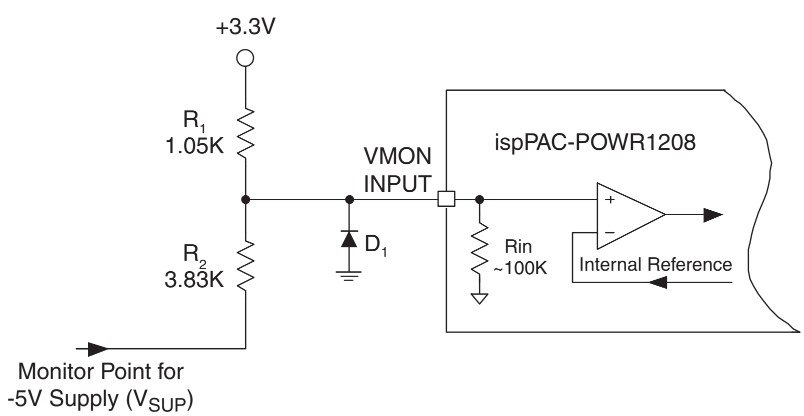


One significant advantage of using this optocoupler-based interface circuit is that it can provide isolation between the ispPAC-POWR1208 and the power circuit being switched. This can be especially useful when controlling high-voltage negative power rails, such as the -48V supplies commonly used in telecommunications equipment. To control a MOSFET switching a -48V rail with this circuit, one would simply connect the optocoupler's collector terminal to a negative voltage supply that would not damage the MOSFET's gate (e.g. -40V).

Monitoring Negative Power Supplies

The other side of controlling a negative power supply is the ability to monitor it. The ispPAC-POWR1208 provides 12 comparator inputs which have programmable thresholds ranging from 1.03V to 5.74V. Simple external circuits, however, can be used to translate negative voltages into positive ones that can be readily monitored by the ispPAC-POWR1208. One such circuit, using only two resistors is shown in Figure 12-4. In this circuit, the two resistors form a voltage divider which is referenced to the 3.3V power supply, and translate a -5V input to a +1.5V output. Diode D_1 is included to protect the ispPAC-POWR1208 against possible undervoltage conditions.

Figure 12-4. Resistive Level-Shifter for Monitoring Negative Supplies



In this circuit the voltage appearing at the ispPAC-POWR1208's VMON input (V_{MON}) can be determined as a function of the voltage at the monitor point (V_{SUP}) by the following equation.

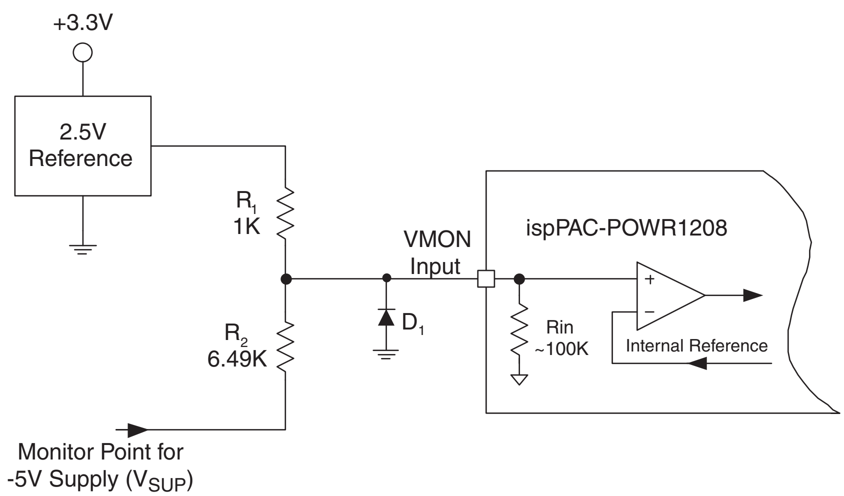
$$V_{MON} = \frac{R_2 V_{REF} + R_1 V_{SUP}}{R_1 + R_2} \quad (1)$$

In this example the 3.3V power supply serves as $V_{REF.}$ This equation ignores the effects of the ispPAC-POWR1208's input loading (~100kΩ). By keeping the divider's output impedance (1.05KΩ || 3.83KΩ ~ 727Ω) much lower than the ispPAC-POWR1208's input impedance, the input loading effects are minimized.

Equation 1 can be used to calculate the threshold which must be set in the ispPAC-POWR1208 to trip at a desired monitor point input voltage. In the above example, a -4% lower limit would be -4.80V, which will result in 1.557V at the ispPAC-POWR1208's input. The nearest threshold provided by the ispPAC-POWR1208 is 1.560V, a mere 3mV difference.

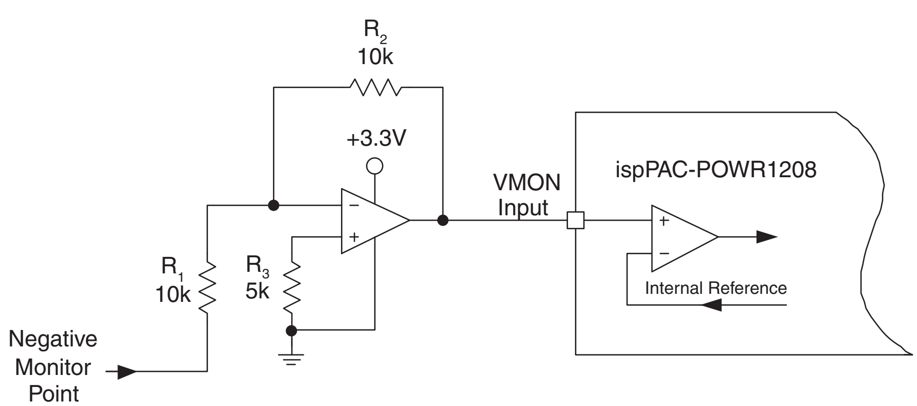
Because $R_2 > R_1$ in this circuit, the voltage appearing at VMON is more sensitive to variations in the +3.3V VREF supply than it is to variations in the V_{SUP} monitored voltage. For this reason it is crucial that this reference voltage be both accurate and stable. One way to significantly improve the accuracy of this circuit is to reference the divider to a precision voltage reference instead of the power rail, as is shown in Figure 12-5.

Figure 12-5. Improved Accuracy Negative Supply Monitor



One drawback of the circuits of Figures 4 and 5 is that the resistive divider attenuates the monitored signal as well as level-shifts it. The circuit of Figure 12-6 gets around this issue by providing unity gain from the monitor point to the ispPAC-POWR1208's input at the cost of an external opamp.

Figure 12-6. Using an Opamp to Monitor Negative Voltages



In this circuit, the opamp provides negative voltage gain, which 'flips' the polarity of the negative monitored signal to a positive value. For example, if -1.5V appears a the monitor point, the opamp will impress 1.5V at the ispPAC-Powr1208's VMON input. Because the opamp's closed-loop output impedance will typically be a few ohms, the isp-PAC-POWR1208's input loading will contribute insignificant levels of error to the measurement. This allows the isp-

PAC-POWR1208's thresholds to be used with just a sign change. Another advantage of this circuit is that its negative-to-positive transformation will be highly accurate, limited by the matching between R_1 and R_2 and the opamp's input offset voltage. With a suitable choice of opamp (input common-mode range includes ground, rail-rail output, and low-voltage operation), the opamp may be operated in single-supply mode from the same supply as the ispPAC-POWR1208, as shown in Figure 12-6.

Conclusion

This application note has shown several techniques for both controlling and monitoring negative power supplies using the ispPAC-POWR1208. The techniques presented are both simple to implement, requiring but a few external discrete components, and cost effective, with total incremental implementation costs as low as a few cents.

Related Literature

- ispPAC-POWR1208 Data Sheet
- ispPAC-POWR604 Data Sheet
- Application Note #AN6050, *Controlling Power MOSFETs Using the ispPAC-POWR604*
- Application Note #AN6048, *Using Power MOSFETs with the ispPAC-POWR1208*
- Application Note #AN6041, *Extending the Input Range of the ispPAC-POWR1208*

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Revision History

Date	Version	Change Summary
—	—	Previous Lattice releases.
April 2008	02.1	Title changed from "Monitoring and Controlling Negative Power Supplies with the ispPAC-POWR1208 and ispPAC-POWR604" to "Monitoring and Controlling Negative Power Supplies with Power Manager Devices."