Lattice Semiconductor Corporation

Adding More Hysteresis to ispPAC-POWR1208 Analog Comparators

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Introduction

The ispPAC®-POWR1208 is a single-chip, fully integrated solution to supervisory and control problems encountered when implementing on-board power conversion and distribution systems. The ispPAC-POWR1208 provides several types of programmable on-chip resources which can be used to meet the requirements of these applications. Twelve analog comparators, each with independently adjustable references provide the ability to detect when a voltage is greater than or less than a given threshold. Four timers make it straightforward to implement programmable delays. An embedded PLD supports the implementation of state machines and sequencers, providing embeddable intelligence in a power supply design. In addition to providing four high-side FET driver outputs, four general purpose open-drain outputs are also provided which can be used to control modular DC-to-DC converters.

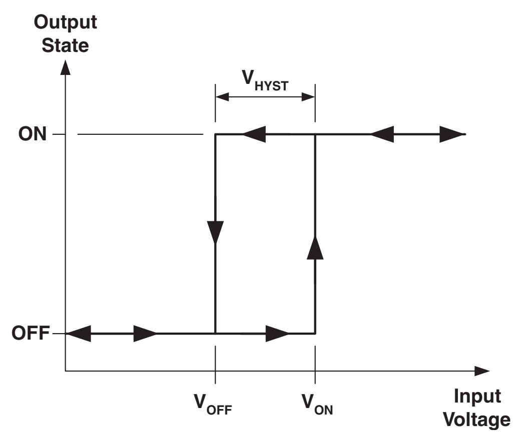
The ispPAC-POWR1208's internal comparators incorporate circuitry to provide a small amount of hysteresis to reduce the effects of noise. In some situations, such as where large amounts of noise are present, it may be desirable to significantly increase the comparator hysteresis. This can readily be accomplished by the addition of inexpensive external components.

What is Hysteresis?

In many applications where comparators are used, a threshold detector determines if an input voltage is greater than or less than a given reference voltage. The ispPAC-POWR1208 provides twelve comparators configured for use in this way, each one with an independently programmable threshold reference voltage. Frequently, when a simple higher-than/lower-than determination is all that is needed, using an analog threshold detector is often preferable to using an analog-to-digital converter and a microprocessor.

When the voltage being measured is either slowly changing, or contains noise, the addition of hysteresis is often useful in a threshold detector. Hysteresis is the difference between the detector's turn-on and the turn-off points. Figure 1 shows the behavior of a comparator incorporating hysteresis.

Figure 1. Example of a Hysteresis Curve



Note that this comparator's response follows two distinct paths, one when it turns on, and another when it turns off. When the input voltage climbs above $V_{ON,}$ the output turns ON, but in order to turn the output back off again, the input voltage needs to drop below $V_{OFF.}$ The hysteresis (V_{hys}) is given by V_{ON} - $V_{OFF.}$

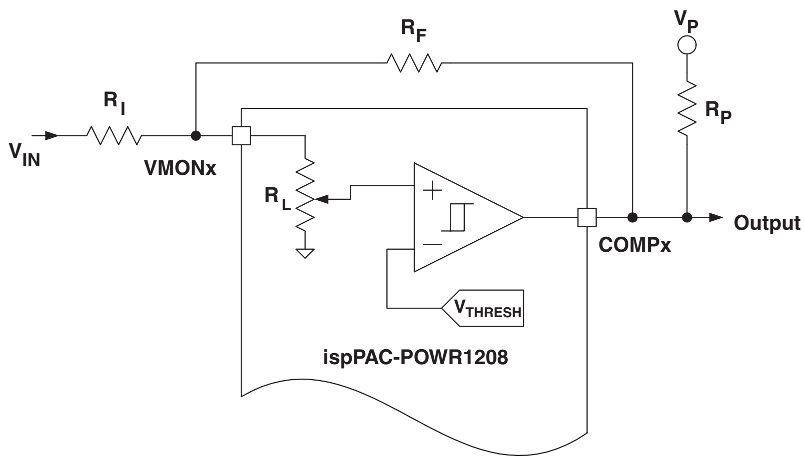
Hysteresis is a useful feature in comparator circuits which must monitor input signals which are either slow-moving or contaminated with noise, because it ensures that small changes in the input signal won't result in changes in output state. A familiar example of how hysteresis is used to this end is in a thermostat that controls a heating or air-conditioning system. When heating a room, the heater or furnace remains on until the room temperature rises to a given threshold, at which point the heater turns off. The room must then cool a small amount (the thermostat's hysteresis value) before the heater will turn on again. Without hysteresis, the heater would rapidly cycle on and off, causing excessive wear on the unit. Similarly, in an electronic circuit, a threshold detector with no hysteresis will often uncontrollably oscillate between its OFF and ON states when its input is near its turn-on threshold. The addition of a small amount of hysteresis to a threshold detector often helps to provide stable operation and a clean transition between the OFF and ON states.

Implementing Additional Hysteresis with ispPAC-POWR1208

The comparators used to implement the ispPAC-POWR1208's analog monitor inputs provide a small amount of hysteresis to ensure clean edge transitions on their outputs. This hysteresis is evenly distributed around the trip-point specified in PAC-Designer®, and is thus indicated as a ± value, with the total hysteresis being twice that displayed (e.g. ±3.4mV = 6.8mV total hysteresis) . The hysteresis is also a function of the selected trip-point, and ranges from (±3.4mV for the lowest trip-point (1.03V) to ±16.2mV for the highest (5.74V). Note that although the ispPAC-POWR1208's hysteresis varies with the comparator setpoint, it remains stable with respect to supply voltage (V_{DD}).

In some circumstances, the user may need to obtain a higher amount of hysteresis than that provided by the ispPAC-POWR1208's comparators. When using analog inputs VMON1 through VMON8, a small amount of external circuitry can be added to increase the effective hysteresis, as shown in Figure 2. This technique is most easily applied to the VMON1 through VMON8 inputs because the outputs of the associated comparators are directly available through dedicated output pins.

Figure 2. Circuit for Increasing the ispPAC-POWR1208's Comparator Hysteresis



The way this circuit operates is as follows. When the output is initially OFF (LOW), resistors R_I and R_F form a resistive divider referenced to ground, and apply a slightly lower signal to the ispPAC device's VMON input terminal. As the input voltage is raised, the VMON input voltage will reach a point at which the comparator, and its output, turn ON (HIGH). When this happens, the R_I / R_F resistive divider now is referenced to V_P through R_P, which causes the voltage at VMON to rise a small amount. In order to turn the output off again, the input voltage now has to drop beneath the value at which it turned on the comparator to counteract the rise in voltage at VMON that was induced by the output being in the ON state. This difference in turn-on and turn-off voltages as seen from V_{IN} is the circuit's effective hysteresis.

While a detailed analysis of this circuit's behavior can be made, if one assumes that $R_F >> R_P$ and $R_L >> R_I$, a simple approximation for hysteresis can be obtained:

$$V_{hyst} = \frac{V_P R_I}{R_F} \tag{1}$$

Because the comparators in the ispPAC-POWR1208 also provide hysteresis, the total hysteresis of the circuit as a whole will be a combination of that provided by the external circuit, and that provided by the comparators themselves.

As an example, consider the problem of implementing an input with 100mV of hysteresis. If V_P is 3.3V, we will want to choose R_P so that it results in less than 4mA of current being sinked by the comparator output when it is in the OFF (LOW) state. A value of 1kΩ for R_P will satisfy this requirement.

The next step is to select a value for R_I. Given that R_P = 1kΩ and V_P = 3.3V, we can rearrange Equation 1 into a form to derive suitable values for R_I and R_F.

$$\frac{R_F}{R_I} \approx \frac{V_P}{V_{hyst}} = \frac{3.3V}{100mV} = 33 \qquad (2)$$

The ratio of R_F to R_I needs to be 33, subject to the constraints that $R_I \ll 100k\Omega$ (the value of R_L), and $R_F \gg R_P$ (which we selected to be 1kΩ). Selecting a value of 1k for R_I and 33k for R_F will satisfy all of these constraints.

As a quick reference guide, Table 1 provides example component values needed to implement a number of selected hysteresis values. Note that the intrinsic hysteresis of the ispPAC-POWR1208's comparators must be added to these values to approximate the true hysteresis.

Table 1. Implementations of Selected Hysteresis Values

V_P	V_{hyst}	R_P	R_F	R_I
3.3 V	10 mV	1 kΩ	330 kΩ	1 kΩ
3.3 V	20 mV	1 kΩ	165 kΩ	1 kΩ
3.3 V	50 mV	1 kΩ	64.9 kΩ	1 kΩ
3.3 V	100 mV	1 kΩ	33 kΩ	1 kΩ
3.3 V	200 mV	1 kΩ	16.5 kΩ	1 kΩ
5.0 V	10 mV	1.5 kΩ	499 kΩ	1 kΩ
5.0 V	20 mV	1.5 kΩ	249 kΩ	1 kΩ
5.0 V	50 mV	1.5 kΩ	100 kΩ	1 kΩ
5.0 V	100 mV	1.5 kΩ	49.9 kΩ	1 kΩ
5.0 V	200 mV	1.5 kΩ	24.9 kΩ	1 kΩ

One significant difference between the hysteresis provided by the ispPAC-POWR1208's internal comparators and that developed by the external network described above is how it is distributed around the trip point. The hysteresis incorporated into the comparators is specified as being symmetric about the trip point, with turn-on and turn-off points equally distant. For hysteresis developed with the external network described above, the actual turn-on and turn-off points are not necessarily balanced around the comparator trip-point.

Conclusion

The ispPAC-POWR1208 provides twelve analog voltage comparators incorporating a small amount of intrinsic hysteresis. In designs where more hysteresis is required, a few external components can be used with comparators 1-8 to provide this function. This application note has described one method for implementing increased hysteresis, and a few of the design issues associated with successful implementation.

Technical Support Assistance

Hotline: 1-800-LATTICE (Domestic)
1-408-826-6002 (International)
e-mail: ispPACs@latticesemi.com
Internet: www.latticesemi.com