Threshold Detector with Programmable Trip-point and Hysteresis Using ispPAC30

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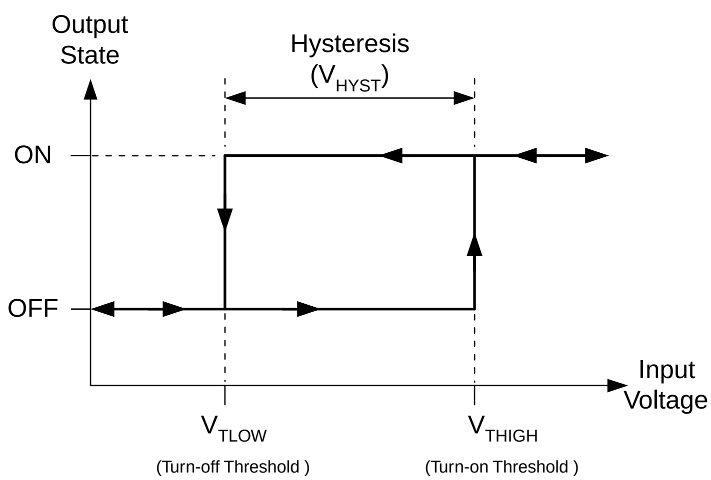
A threshold detector can be thought of as a single-bit analog-to-digital converter. In applications where a simple higher-than/lower-than determination is all that is needed, using an analog threshold detector is often preferable to using an analog-to-digital converter and a microprocessor.

When the variable being measured is either slowly changing, or contains noise, the addition of hysteresis is often useful in a threshold detector. Hysteresis is a difference between the turn-on and the turn-off points of the detector. A thermostat that controls a heating or air-conditioning system provides a good example of a system in which hysteresis is useful. 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 provides a clean transition between the OFF and ON states. Figure 1 shows the transfer function of a threshold detector with hysteresis. Note that the function follows two distinct paths, one when it turns on, and another when it turns off.

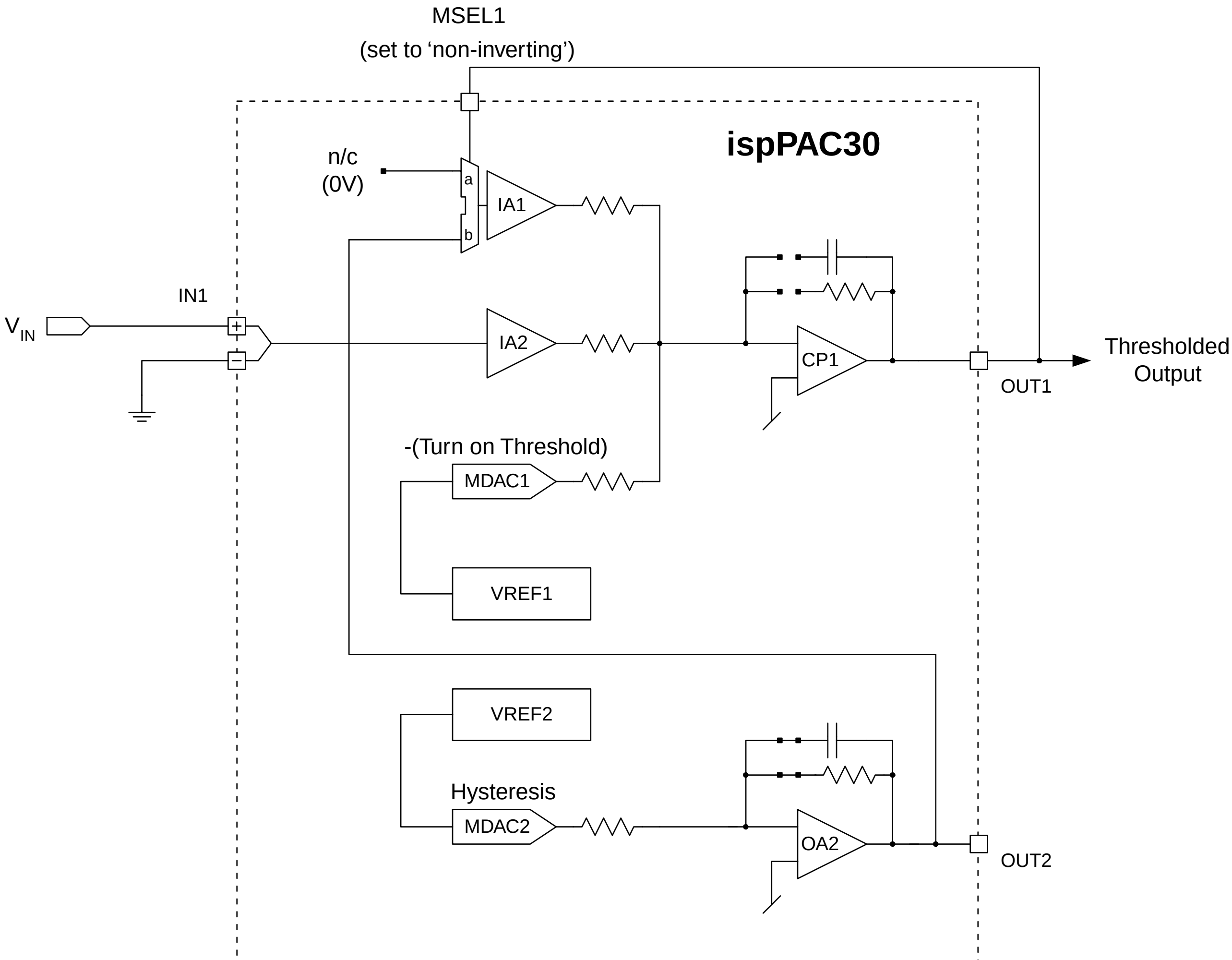
Figure 1. Effect of Hysteresis in a Threshold Detector



While there are numerous ways in which to implement threshold detectors, many of these require components (typically resistors) to be selected to set a desired turn-on point and hysteresis. The circuit shown in Figure 2, which is implemented with a single Lattice Semiconductor ispPAC®30, allows one to set both the turn-on point and the hysteresis voltage by setting the on-chip MDACs, as opposed to placing different resistors on the board. Furthermore, these values can be set completely independently of each other; i.e. changing the hysteresis does not change the turn-on threshold.

In this circuit, the turn-on point V_{THIGH} is set by the combination of VREF1 and MDAC1, and the hysteresis (V_{HYST}) is independently set by the combination of VREF2 and MDAC2. Note that the voltage at the output of MDAC1 needs to be set to *negative* V_{THIGH}. When the circuit is in the OFF (OUT1 = 0V) state, and the input voltage (V_{IN}) is less than V_{THIGH}, the voltage at the input of CP1 will be less than zero. The output of CP1 will therefore be OFF (0V). The IA1 input multiplexor will select it its unconnected input (0V) and therefore make no contribution to CP1's input voltage.

Figure 2. ispPAC30 as Programmable Threshold Detector



When V_{IN} exceeds V_{THIGH}, the input voltage at CP1's input becomes positive. This causes the output of CP1 to turn ON (OUT1 = 5V). As a result of this change, IA1's input multiplexor selects the 'b' input, which adds the hysteresis voltage (developed by VREF2 and MDAC2) into the input of CP1. This added voltage reinforces CP1's ON condition. Once CP1 is ON, V_{IN} must drop to V_{TLOW} (V_{THIGH} - V_{HYST}) before CP1 will return to the OFF condition. One advantage of using IA1's multiplexor for positive feedback is that because the hysteresis voltage is set by a precision on-chip reference, it is both accurate and independent of the power supply voltage. Additionally, by varying IA2's gain it is possible to scale down trip-point and hysteresis voltages to much smaller ranges.

In addition to being able to set the values for the turn-on threshold and the hysteresis at end-of-line manufacture in E^2 memory, these parameters can be dynamically reprogrammed while the system is operating through the ispPAC30's SPI interface port.

Technical Support Assistance

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