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TUTORIAL 589

CPU Supervisors: Frequently Asked Questions (FAQs)

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Abstract: This application note explains the function of a CPU supervisor and how it can monitor a system. The article discusses the function of a watchdog timer, chip-enable gating pin, and a sense input for an early warning signal. The document also focuses on the difference between a reset circuit and a voltage detector, and advises how to choose the proper voltage threshold.

What Is the Function of a Watchdog?

The watchdog timer allows the supervisor to monitor and restart a processor. In simplest terms, the watchdog timer restarts a clock each time that a transition occurs on its input. If the clock times out, then a reset or watchdog status output goes active. The input for the watchdog can be derived from many processor or system signals. Some of the most commonly used signals include data/address I/Os and interrupt outputs. In many cases a processor stalls because of a power transient, data, or software error. Monitoring processor operation can allow the supervisor to restart a stalled processor when no actual system problem exists. This capability saves some cost in system service personnel and can reduce downtime.

For example, the MAX16056 is a low-power (125nA) supervisor with a capacitor-adjustable watchdog timeout and reset. This device asserts an active-low reset signal to the processor whenever the watchdog timer runs out or when the monitored voltage falls below the set threshold. The reset output remains asserted for the duration of the reset timeout.

What Is the Difference between a Reset and a Voltage Detector?

Voltage detectors simply indicate that a voltage is above or below a specific value. They do not provide any timing delays and generally have very limited noise immunity. One example of a voltage detector is the MAX16012, a single-voltage detector that can be configured for overvoltage or undervoltage monitoring. The open-drain output asserts low when the monitored voltage exceeds (above or below) the set threshold. The output deasserts when the monitored voltage returns to normal operating range.

Resets provide a digital signal to the processor that not only indicates the voltage level, but also delays the reset signal so that the voltage can arrive at its nominal value. That delay also allows the power supply and board to fully stabilize prior to restarting operation. The MAX16056 is a supervisory circuit with a reset timeout. When the monitored voltage falls below the reset threshold, the active-low RESET output asserts. When the monitored voltage rises above the threshold (plus hysteresis), an internal counter holds the active-low RESET low for the reset timeout period. Active-low RESET deasserts only after the reset timeout period. The MAX16056 reset timeout period is capacitor selectable.

How Do I Choose a Reset Threshold and Tolerance?

Generally speaking, the supervisory device's reset threshold should be set at or below the lowest power-supply output voltage. For example, a 3.3V power supply rated at ±5% has a minimum output voltage of 3.135V. The appropriate supervisory reset threshold should have a maximum voltage of 3.135V or less. A supervisory device with a 3.059V nominal reset threshold and a tolerance of 2.5% has a maximum threshold voltage of 3.135V, which is ideal. In some cases it is a good idea to choose a lower reset threshold to account for power-supply glitches or noise.

To choose the supervisor's reset threshold tolerance, look at the minimum operating voltage of the microprocessor or any other device connected to the microprocessor. The minimum reset threshold should be higher than the minimum voltage needed for the microprocessor and associated support components to operate. For example, a microprocessor needs at least 2.7V to operate, which means that the minimum reset threshold has to be greater than 2.7V. Using the example supervisory device from the previous paragraph, the nominal reset threshold is 3.059V, and the minimum reset threshold (2.5% tolerance) is 2.983V, which is above 2.7V.

I Need to Monitor Two Supply Rails. What Do You Have?

Similarly, the MAX6715A monitors two voltages (up to 5.5V) independently. Voltage thresholds for the inputs range from 0.788V to 4.625V, are factory set, and are independent of one another. The MAX6715A features two active-low open-drain reset outputs that assert low when corresponding monitored voltages fall below set thresholds. The MAX6716A is similar to the MAX6715A, but features push-pull outputs.

To What Does Device Tolerance Refer in CPU Supervisors?

Device tolerance can be used to refer to two different device values. One value is the voltage at which the device recognizes that power is good. On Maxim devices this value would generally be indicated simply as a percentage (for example, 5%). It would indicate that the device will trip just below the operating voltage minus 5%.

The other tolerance value is the variation or the accuracy of the trip point around its center point. In most cases this would be cited as plus or minus some percentage (e.g., ±2.5%). Generally, most products supplied by Maxim operate with a ±2.5% reset threshold tolerance.

What Is a Sense Input and NMI Output? What Are the PFI/PFO Connections?

The (sense) input or PFI (power-fail input) and NMI (nonmaskable interrupt) output or PFO (power-fail output) are found on many CPU supervisor products. These functions can be configured to monitor an upstream voltage and, thus, provide an early warning of an impending power failure. This warning allows time to save critical data. In this application, the NMI/PFO output would generally be connected to a processor's NMI input. They also monitor secondary system voltages and provide a "system not ready" indicator to provide more consistent system operation. In this application, the NMI/PFO output can be connected to a processor interrupt, pushbutton reset input, or other control inputs.

What Are CEI/CEIN and CEO/CEOUT Pins on Many of the CPU Supervisory Components?

A CEI (chip-enable input) and CEO (chip-enable output) provide a method to control RAM chip enable, based on the value of V_{CC}. The CEI is typically connected to a processor address output, RAM decode output, or directly to ground if the RAM is always enabled. The CEO is typically connected to the CE input on the RAM. This configuration allows the RAM to be automatically deselected if the voltage on V_{CC} is below the value rated to protect data during power transients. If not used, CEI would typically be connected to ground and CEO would be left floating.

Note: On devices with the prefix "MAX," CEI and CEO are labeled as CEIN and CEOUT.

What Is the Largest Capacitor Allowed for the Programmable Delay on Maxim CPU Supervisors?

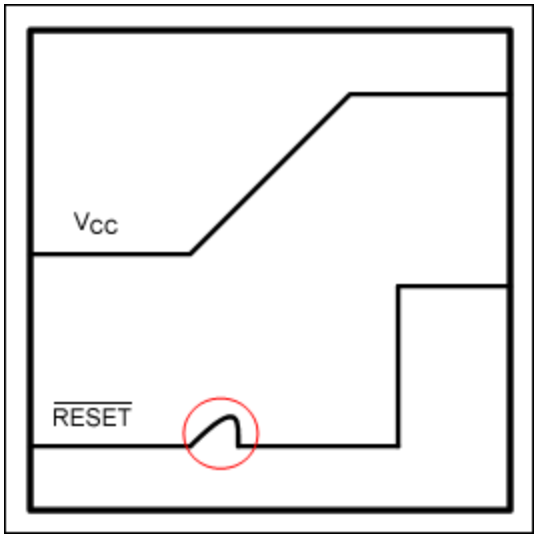
The maximum capacitor size for the programmable delay is determined by the maximum leakage current. The larger the capacitor, the higher the capacitor quality needed to keep the leakage current below the capacitor charge current supplied by the device. Capacitors with leakage current ratings that exceed the charge current will never charge.

Can Active-Low RESET Remain Low even When V_{CC} Falls Below the Minimum Operating Voltage?

On many parts active-low RESET can sink current even when V_{CC} is below the minimum operating voltage. However, the sink current falls dramatically once V_{CC} falls below ~0.7V to ~0.5V.

What Is the "Glitch" on RESET (Active-Low Open-Drain) During Power Up?

The following waveform is often observed in systems with an active-low open-drain reset:



The glitch (circled area) is caused by the pullup resistor connected to the RESET output. For a short time during power-up, V_{CC} is too low for the RESET output driver to overcome the pullup resistor, and the RESET output will track V_{CC}. Once V_{CC} reaches 0.5V to 0.9V (depending on the device) RESET will go low.

In most cases this is not a problem, since the V_{CC} voltage is well below the operating range of other devices in the circuit. In cases where this is a problem, it is a good idea to use a supervisor with a push-pull RESET output. If needed, a resistor can be connected from RESET to ground.

What Is the Recommended Size of the Pullup Resistor for an Open-Drain, Active-Low RESET Output?

The resistor size depends on the application. Most applications can use a 10kΩ pullup resistor, although that value should be increased for applications requiring lower power dissipation. When selecting a resistor value, make sure that the current into the switch (internal to the device) does not exceed the value listed in the Electrical Characteristics table of the device's data sheet. This will ensure the output low voltage when active-low RESET is low.

What Supervisor Devices Does Maxim Offer?

Microprocessor supervisors come in many versions. Supervisors can monitor more than just one voltage, and have dual-/triple-/quad-/quint-voltage monitoring capabilities. Some supervisors are coupled with voltage-sequencing features to provide sequence timing as well as independent monitoring of each voltage. The latest microprocessor-supervisor devices can be found by visiting the supervisors home page. Some devices and short descriptions are listed in **Table 1**.

Table 1. CPU Supervisors—Recent Product Releases

Supervisor	Description
MAX6715A, MAX6716A	Dual/triple-voltage, microprocessor supervisors with watchdog, manual reset Input, and/or power-fail comparator.
MAX6730A	Single-voltage microprocessor supervisory circuit with independent watchdog output monitor down to 0.63V.
MAX16012	Ultra-small, low-power, overvoltage protection circuit for high-voltage, high-transient systems such as those found in automotive, telecom, and industrial applications.
MAX16016, MAX16020, MAX16021	Industry's most highly integrated microprocessor supervisor circuits provide battery backup and CE gating.
MAX16023, MAX16024	Low-power battery-backup circuits with regulated output reduce the total number of external components.
MAX16056	Ultra-low-current 125nA (typ) microprocessor supervisory circuit that monitors a single system supply voltage.
DS3600	Secure supervisor with 64B nonimprinting, battery-backed, encryption key SRAM provides security, tamper detection, encryption key storage, and encryption key destruction in event of a tamper event.
DS3650	NV SRAM controller, RTC, and supervisor with tamper detection provides security, and encryption-key destruction in event of a tamper event.

Related Parts		
MAX16012	Ultra-Small, Overvoltage Protection/Detection Circuits	Free Samples
MAX16056	125nA Supervisory Circuits with Capacitor-Adjustable Reset and Watchdog Timeouts	Free Samples
MAX6715A	Dual/Triple, Ultra-Low-Voltage, SOT23 µP Supervisory Circuits	Free Samples
MAX6716A	Dual/Triple, Ultra-Low-Voltage, SOT23 µP Supervisory Circuits	

More Information
For Technical Support: http://www.maximintegrated.com/support
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Application Note 589: http://www.maximintegrated.com/an589
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