AN802

Selecting a Processor Reset IC

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INTRODUCTION

Microcontroller and microprocessor based systems rely on processor supervisory functions to insure stable operation. The most basic of all these functions is managing the processor reset input. To ensure stable operation, the processor must be held in reset any time supply voltage is out-of-tolerance. Once supply voltage is in-tolerance, the processor must be maintained in reset for an additional time period to ensure a stable start-up. The processor reset function may be contained on-board the processor itself, or may be externally implemented using discrete components or a supervisor IC.

RESET CONTROL ON-BOARD THE PROCESSOR

Many processors have integrated supervisor circuitry. For example, the supervisor on-board the PIC16C74 microcontroller allows software execution to begin 72msec after the supply voltage is above a preset threshold (“in the range of 1.6V to 1.8V”, according to the Microchip data sheet). This appears to be a desirable feature that would eliminate the need for an external supervisor. Closer observation shows otherwise.

First, the stated reset threshold voltage “in the range of 1.6V to 1.8V” is neither guaranteed nor specified in the DC characteristics table for this device. A non-precise reset threshold may inhibit processor operation when the supply voltage is low, but still within tolerance; or (worse) allow the processor to run at substandard supply voltages, resulting in unstable processor operation.

Second, a reset time delay of 72msec is often too short to ensure the rest of the system has enough time to stabilize, again resulting in unpredictable system operation. This is especially true if the power supply ramp-up is slow. To compensate for this deficiency, an external resistor, capacitor and diode need to be added as shown in Figure 1. This circuitry increases reset time delay by overriding the internal supervisor circuitry.

Extending power supply reset time delay as shown in Figure 1 is not without its unwanted side effects. The reset signal must be immediately asserted when power supply voltage falls (due to power down or brown-out condition). The response time of the circuit shown in Figure 1 to a falling supply voltage is very slow, thanks to the ponderous timing capacitor to ground. To overcome this deficiency, additional circuitry (Figure 2) is needed.

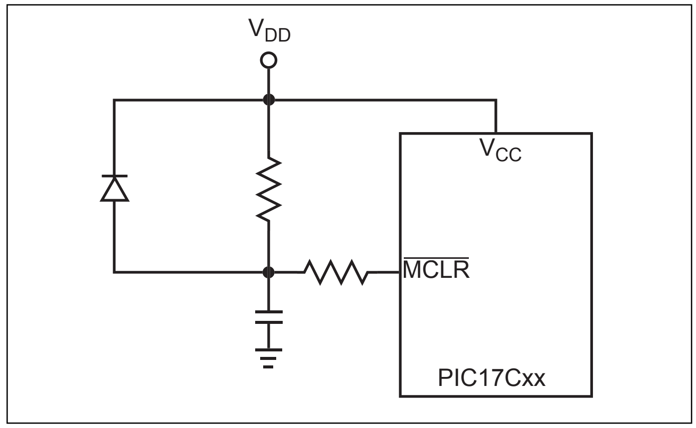

FIGURE 1: *Additional reset circuitry for slow V_{DD} ramp.*

This circuit attempts to drive reset active when supply voltage falls below $V_Z + V_{BE}$ (and again rely on the time delay circuit on-board the processor). However, the values of critical device parameters (i.e. h_{FE}, V_{BE}, V_Z) vary widely with temperature, making circuit behavior unpredictable (and possibly not manufacturable).

Some microcontrollers are specifically designed to monitor falling supply voltage, such as the PIC16C62x. The brown out detection accuracy is typically ±5%, possibly adequate for only some applications. At best, integrated brown out circuit is marginally effective, and often must be supplemented with a precision low voltage detector to perform a reliable hardware reset.

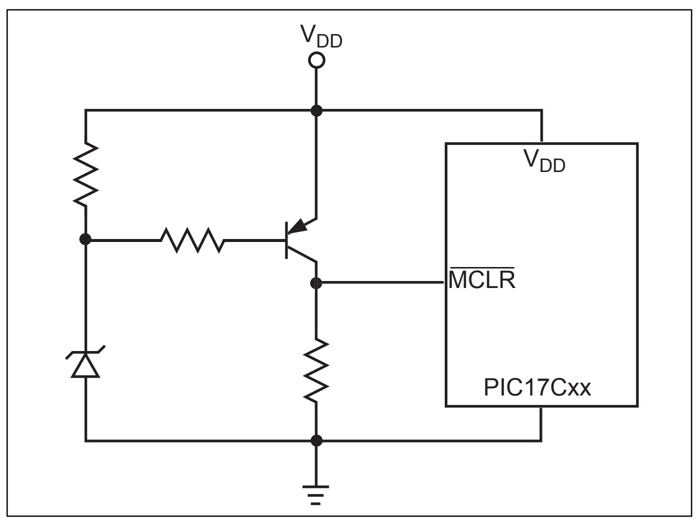

FIGURE 2: *Power-down and brown out protection circuitry.*

DISCRETE SUPERVISORY CIRCUITS

Implementing supervisory functions using discrete components consumes excessive board space and usually results in an over-priced, unreliable solution. Detection accuracy suffers from the additive effects of component tolerances (which only worsen over temperature). Discrete solutions that would provide desirable detection accuracy (e.g. ±2.5% or better) require tight tolerance, low temperature coefficient resistors and voltage references, and comparators with low input offset voltages. Components of these types are sold at premium prices.

Another key consideration is power supply noise rejection. Supply "glitches" can be mistaken for a low supply condition by discrete supervisor circuits (or for that matter, supervisors integrated on-board the processor). Unwanted resets will be issued as a result. The additional circuitry required to make such circuits noise-immune can be considerable.

INTEGRATED PROCESSOR SUPERVISOR ICs

The TCM809/810 and TC54V reset supervisors offer benefits of small size (SOT-23-3 packages), high precision, and low installed cost. The TCM809/810 combine precision supply detection with an integrated reset timer, and are optimized for good power supply noise rejection. The TC54V is a stand-alone supply detector.

On power-up, the TCM809/810 continuously monitors the supply for an in-tolerance condition. The RESET (or RESET for TCM810) output remains active for an additional 140msec following detection of an in-tolerance supply condition to allow time for the system to stabilize. Unlike discrete supervisor circuits, the RESET (or RESET) output is immediately driven and held active whenever the supply is out-of-tolerance. Five different versions of the TCM809/10 are available, providing different reset threshold options for 3V and 5V systems. The reset threshold accuracy is ±2.5% across the –40°C to +85°C temperature range. The reset output is valid for supply voltages as low as 1.0V, well below minimum operating voltages of most systems.

The TC54 series are precision voltage detectors in SOT-23-3, SOT-89-3 and TO-92 packages. The TC54 is available with a CMOS (TC54VC) or N-channel open drain (TC54VN) RESET outputs. Both versions are offered with detection threshold accuracy of ±1.6% and ±2.5% across a –40°C to +85°C range. The detection thresholds can be specified between 1.5V and 6.0V in 100mV steps. The output on the TC54 is valid down to a minimum of 1.5V.

The TC54VC asserts RESET when V_{CC} falls below the detection threshold. An RC circuit is added to the open drain output of the TC54VN series to implement the required reset delay. Increasing the value of the resistor increases the delay time (see Figure 3).

One of the most common microcontrollers, the Motorola 68HC11 family, recommends the MC34164-3 and the MC34164-5 for processor supervision in 3V and 5V systems, respectively. The MC34164-3 only provides a ±3.7% reset threshold accuracy. The TCM809R and TC54VN2702 can be used as upgrades, providing better (±2.5%) accuracy in a smaller package (see Figure 4 and Table 1).

The MC34164-5 provides a ±2.8% reset threshold accuracy. Again, the TCM809M or the TC54VN4402 can be used as upgrades, also providing improved accuracy in a smaller SOT-23-3 package (see Figure 5 and Table 1). TC54VN and TCM809 can also be used to replace the MC33064 and MC34064 reset ICs (see Table 1).

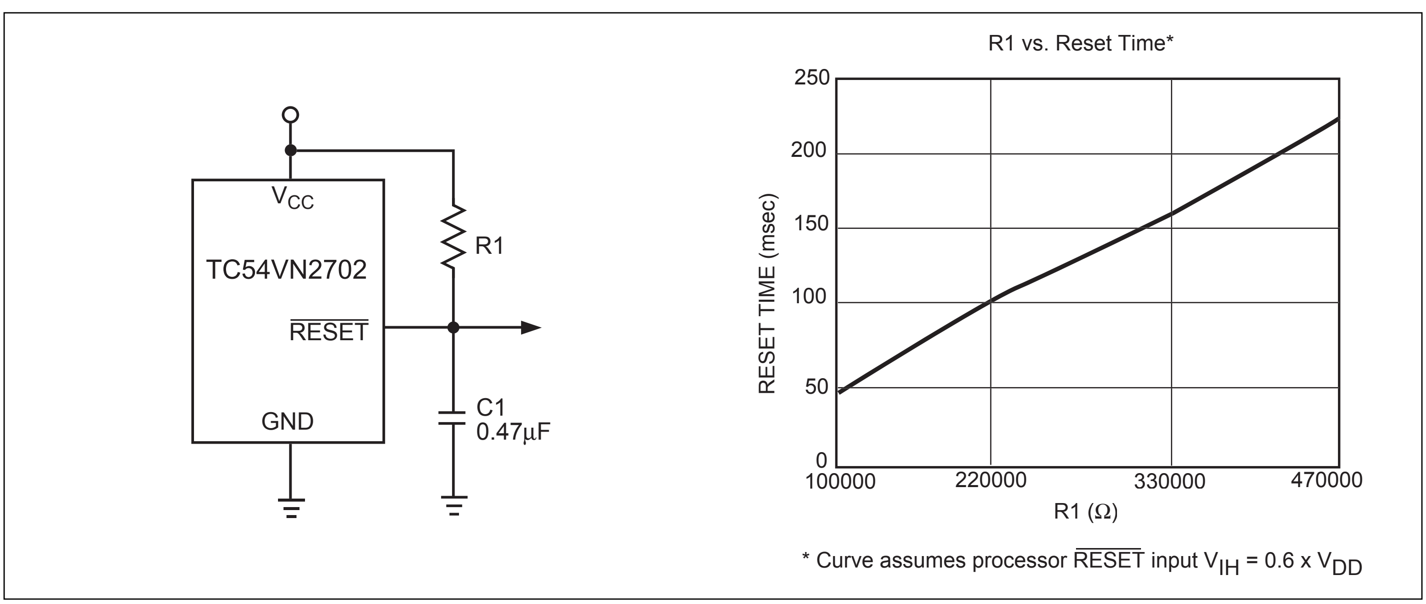

FIGURE 3: *Setting TC54VN delay time.*

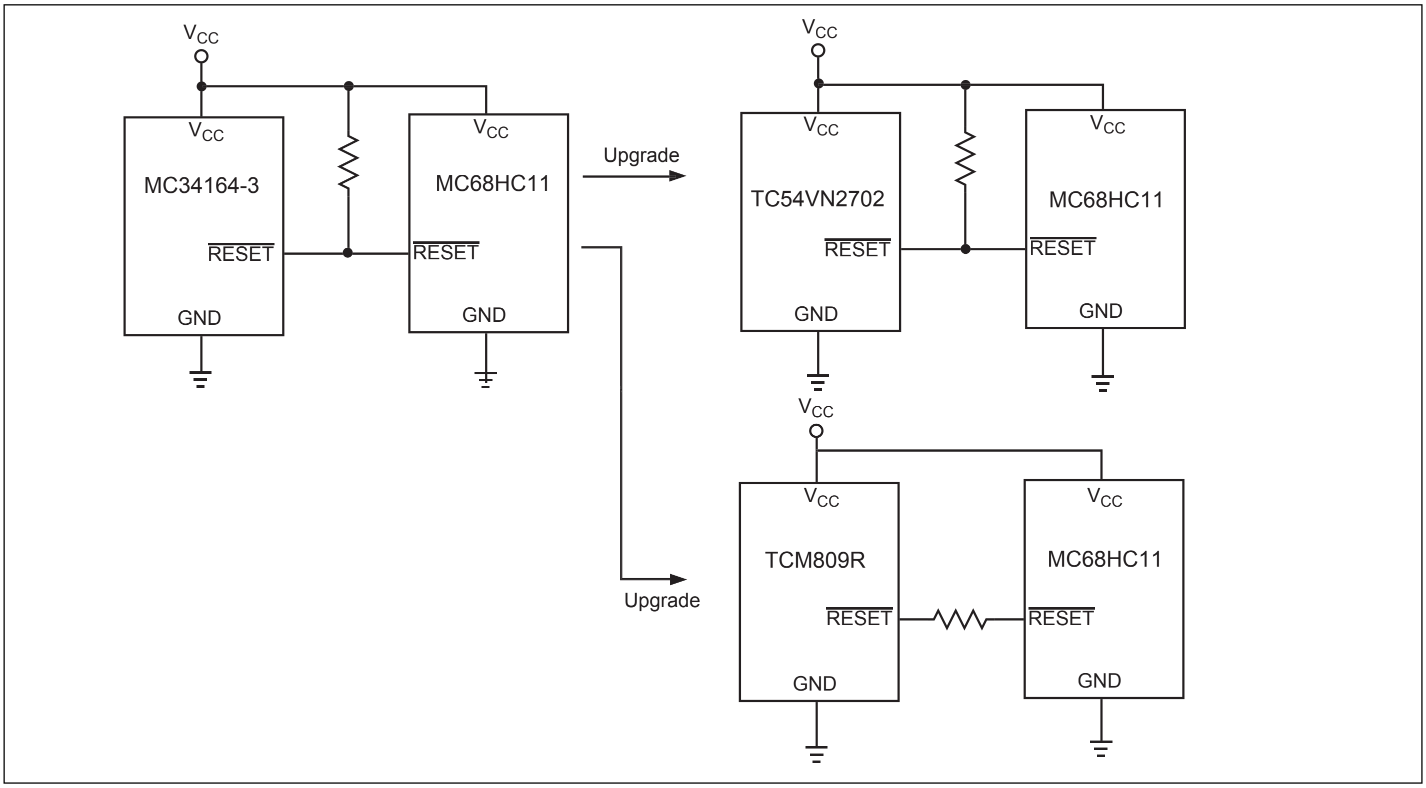

FIGURE 4: *Upgrading 68HC11 processor supervisor.*

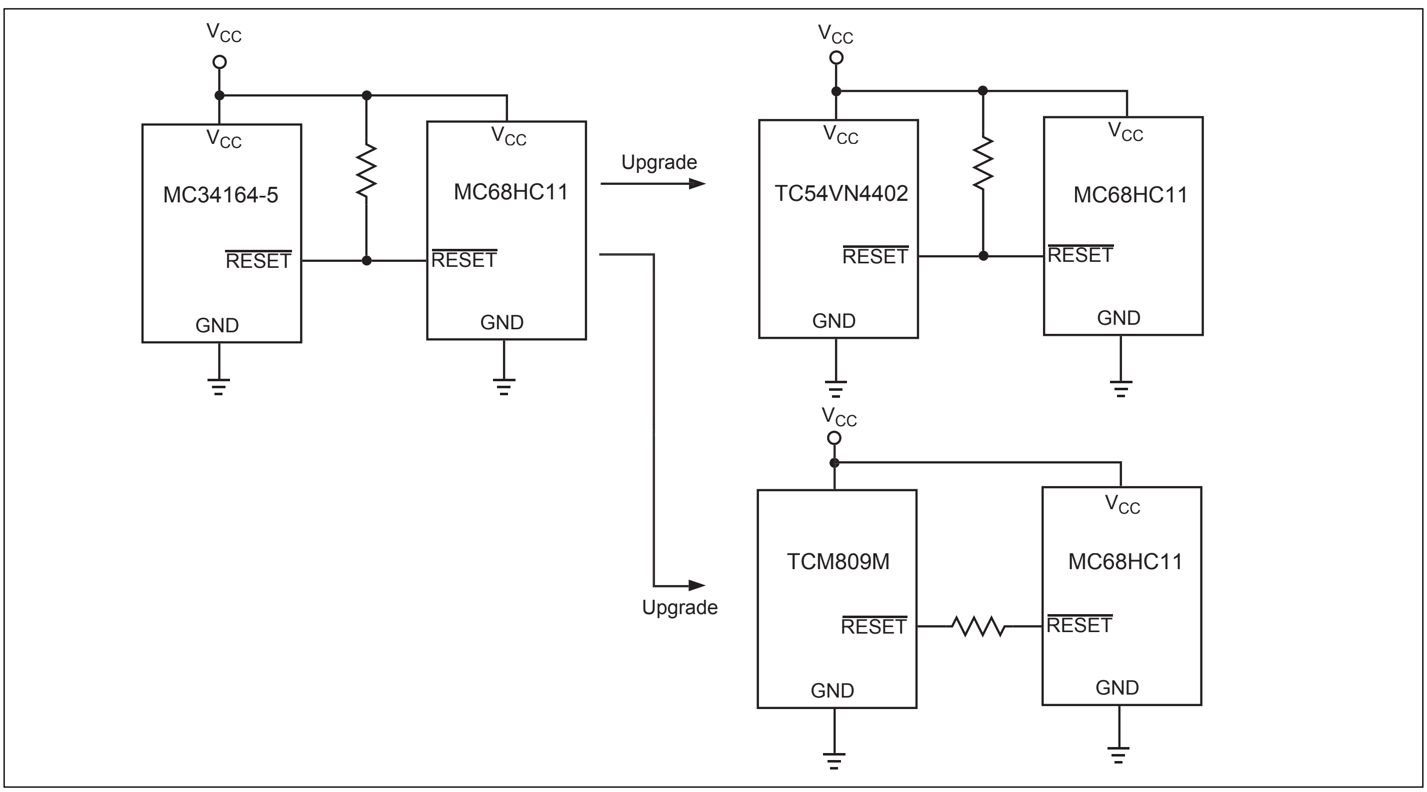

FIGURE 5: *Upgrading 68HC11 processor supervisor.*

System Supply	Device	Package	Reset Accuracy	Min Reset	Max Reset
3V	MC33164-3	SO-8, TO-92	±3.7	2.55V	2.80V
3V	MC34164-3	SO-8, TO-92	±3.7%, (0°C – 70°C)	2.55V	2.80V
3V	TCM809R	SOT-23-3	±2.5%	2.55V	2.70V
3V	TC54VN2702	SOT-23-5, TO-92	±2.6%	2.629V	2.771V
5V	MC33164-5	SO-8, TO-92	±2.8%	4.15V	4.45V
5V	MC34164-5	SO-8	±2.8%, (0° –70°C)	4.15V	4.45V
5V	TCM809M	SOT-23-3	±2.5%	4.25V	4.5V
5V	TC54VN4402	SOT-23-3, TO-92	±2.6%	4.286V	4.5V
5V	TC54VN4302	SOT-23-3, TO-92	±2.6%	4.188V	4.41V
5V	MC33064-5	SO-8, TO-92	±2.4%	4.5V	4.7V
5V	MC34064-5	SO-8, TO-92	±2.4% (0°C – 70°C)	4.5V	4.7V
5V	TCM809L	SOT-23-3	±2.5%	4.5V	4.75V
5V	TC54VN4601	SOT-23-3, TO-92	±1.6%	4.525V	4.674V
5V	TC54VN4602	SOT-23-3, TO-92	±2.6%	4.48V	4.73V

Note: Reset accuracy is guaranteed from – 40°C to +85°C unless noted otherwise.

TABLE 1: *Setting TC54VN delay time.*

FACTORS DETERMINING SELECTION OF A RESET THRESHOLD

Worst case power supply and system tolerances must be taken into account when deciding a reset threshold voltage. Power supply output voltage changes with input voltage, output load and temperature (typical processor power supplies are specified to operate at 3V or 5V with ±5% or ±10% tolerances). Table 2 compares reset threshold options for typical systems based upon power supply tolerances and minimum operating voltages. Minimum system operating voltage, is defined as the lowest supply voltage that will still support normal system operation. This voltage level is usually calculated based on minimum operating voltages of all components in the system, plus added guardband. The power supply voltage tolerance and minimum system operating voltage are key factors in determining a reset threshold voltage.

Power Supply				Reset				System
V_{CC}	Tolerance	V_{CC} Min	V_{CC} Max	Device	Accuracy	Min Reset	Max Reset	Min Op Voltage
5V	±5%	4.75V	5.25V	TCM809/10L	±2.5%	4.5V	4.75V	4.75V
				TC54Vx4702	±2.5%	4.58V	4.82V	4.75V
				TC54Vx4602	±2.5%	4.48V	4.73V	4.75V
				TC54Vx4701	±1.6%	4.625V	4.775V	4.75V
				TC54Vx4601	±1.6%	4.525V	4.674V	4.75V
5V	±10%	4.5V	5.5V	TCM809/10M	±2.5%	4.25V	4.5V	4.5V
				TC54Vx4402	±2.5%	4.286V	4.504V	4.5V
				TC54Vx4401	±1.6%	4.330V	4.470V	4.5V
3V	±5%	2.85V	3.15V	TCM809/10S	±2.5%	2.85V	3.0V	3.0V
				TC54Vx2802	±2.5%	2.727V	2.873V	3.0V
				TC54Vx2801	±1.6%	2.755V	2.846V	3.0V
				TCM809/10R	±2.5%	2.55V	2.70V	2.7V
				TC54Vx2602	±2.5%	2.531V	2.669V	2.7V
				TC54Vx2702	±2.5%	2.629V	2.771V	2.7V

TABLE 2:

Power Supply				Reset				System
V_{CC}	Tolerance	V_{CC} Min	V_{CC} Max	Device	Accuracy	Min Reset	Max Reset	Min Op Voltage
3V	±5%	2.85V	3.15V	TC54Vx2601	±1.6%	2.557V	2.643V	2.7V
				TC54Vx2701	±1.6%	2.656V	2.745V	2.7V
				TC54Vx2801	±1.6%	2.755V	2.846V	2.7V
3V	±10%	2.7V	3.3V	TCM809/10T	±2.5%	3.0V	3.15V	3.0V
				TCM809/10S	±2.5%	2.85V	3.0V	3.0V
				TC54Vx2802	±2.5%	2.727V	2.873V	3.0V
				TC54Vx2902	±2.5%	2.825V	2.975V	3.0V
				TC54Vx2801	±1.6%	2.755V	2.846V	3.0V
				TC54Vx2901	±1.6%	2.87V	2.93V	3.0V
3V	±10%	2.7V	3.3V	TCM809/10R	±2.5%	2.55V	2.7V	2.7V
				TC54Vx2602	±2.5%	2.531V	2.669V	2.7V
				TC54Vx2702	±2.5%	2.629V	2.771V	2.7V
				TC54Vx2601	±1.6%	2.557V	2.643V	2.7V
				TC54Vx2701	±1.6%	2.656V	2.745V	2.7V

Note: All reset thresholds are guaranteed from – 40°C to +85°C.

TABLE 2 (CONT):

RESET THRESHOLD BASED ON SUPPLY TOLERANCE ALONE

Figure 6 shows the relationship between threshold voltages of various processor supervisor ICs and system supply voltage levels. If power supply tolerance is the only consideration in selecting the reset threshold, the TCM809T is the best device for the application shown. Choosing the reset threshold in this way is advantageous in that it guarantees system reset is at or above the minimum operating voltage. It may be less than desirable however, because reset can be asserted when the power supply is still within tolerance, causing unnecessary interruptions in system operation.

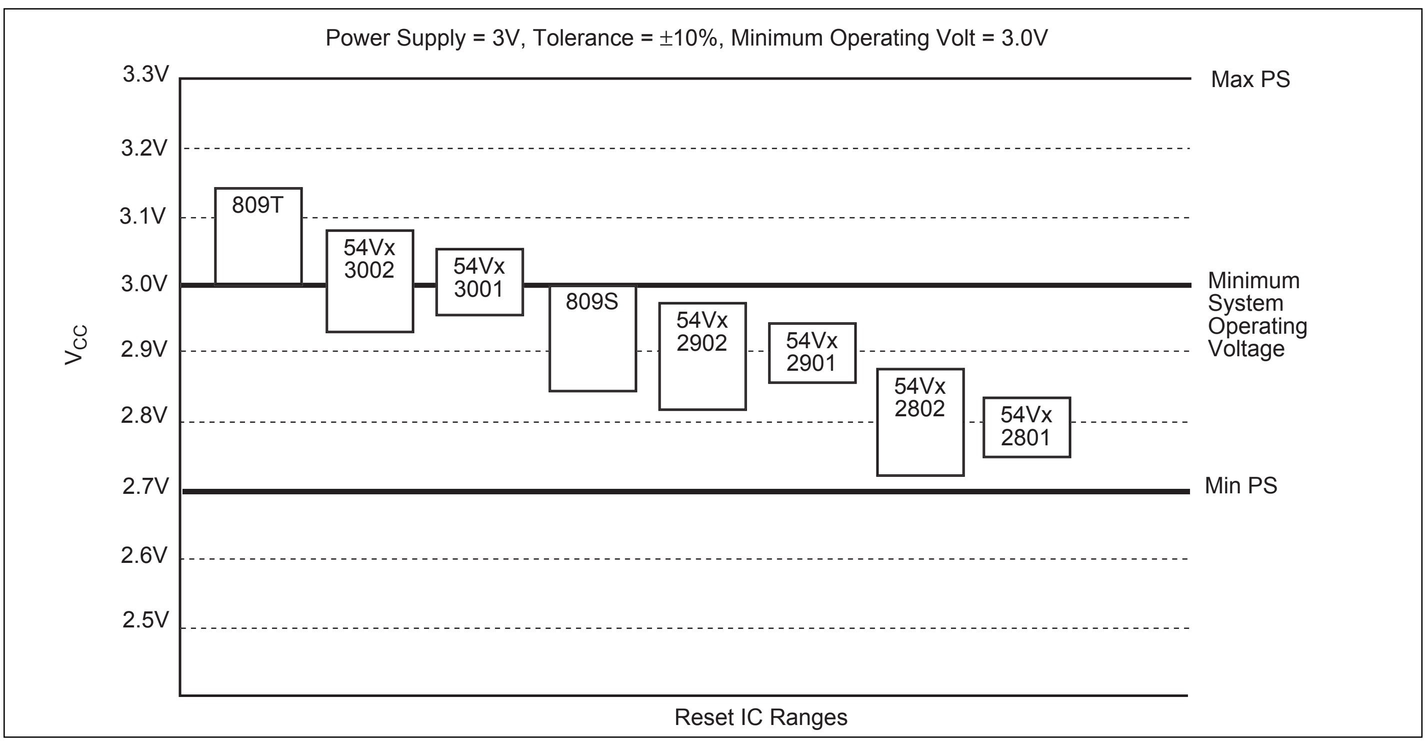

FIGURE 6: *Processor supervisor IC thresholds vs. supply voltage.*

RESET THRESHOLD AS A FUNCTION OF MINIMUM SYSTEM OPERATING VOLTAGE

To reduce the chance of asserting reset while the power supply is in tolerance, thresholds below the operating voltage can be selected. Most ICs are fully functional below their minimum specified operating voltage because manufacturers incorporate operating voltage guardbands. In some cases, these guardbands can be as high as several hundred millivolts. Consequently, it is widely acceptable to select a reset threshold close to, but below, the minimum operating voltage. A good example of such a reset threshold is the TCM809S and TC54Vx2902 shown in Figure 6. To reduce the effect on system reliability, tighter tolerance reset thresholds can be selected, such as the TC54Vx01 detectors with ±1.6% accuracy.

IDEAL SITUATION

The best scenario is a tight tolerance power supply driving a system whose minimum operating voltage is well below the minimum power supply voltage (Figure 7). In this case, the maximum reset voltage threshold can be chosen equal to the minimum power supply voltage. This causes reset to be asserted when the supply is at the lower limit of its in-tolerance range, yet well above the minimum system operating voltage. The TC54Vx2801 in Figure 7, for example, represents the best threshold voltage option for the system voltages shown.

SUMMARY

Microchip's TCM809/10 and TC54 series of products provide a wide variety of reset options that meet the reset requirements of most systems. These ICs provide a solution that is more reliable, easily implemented and as cost effective as discrete and on-processor circuitry.

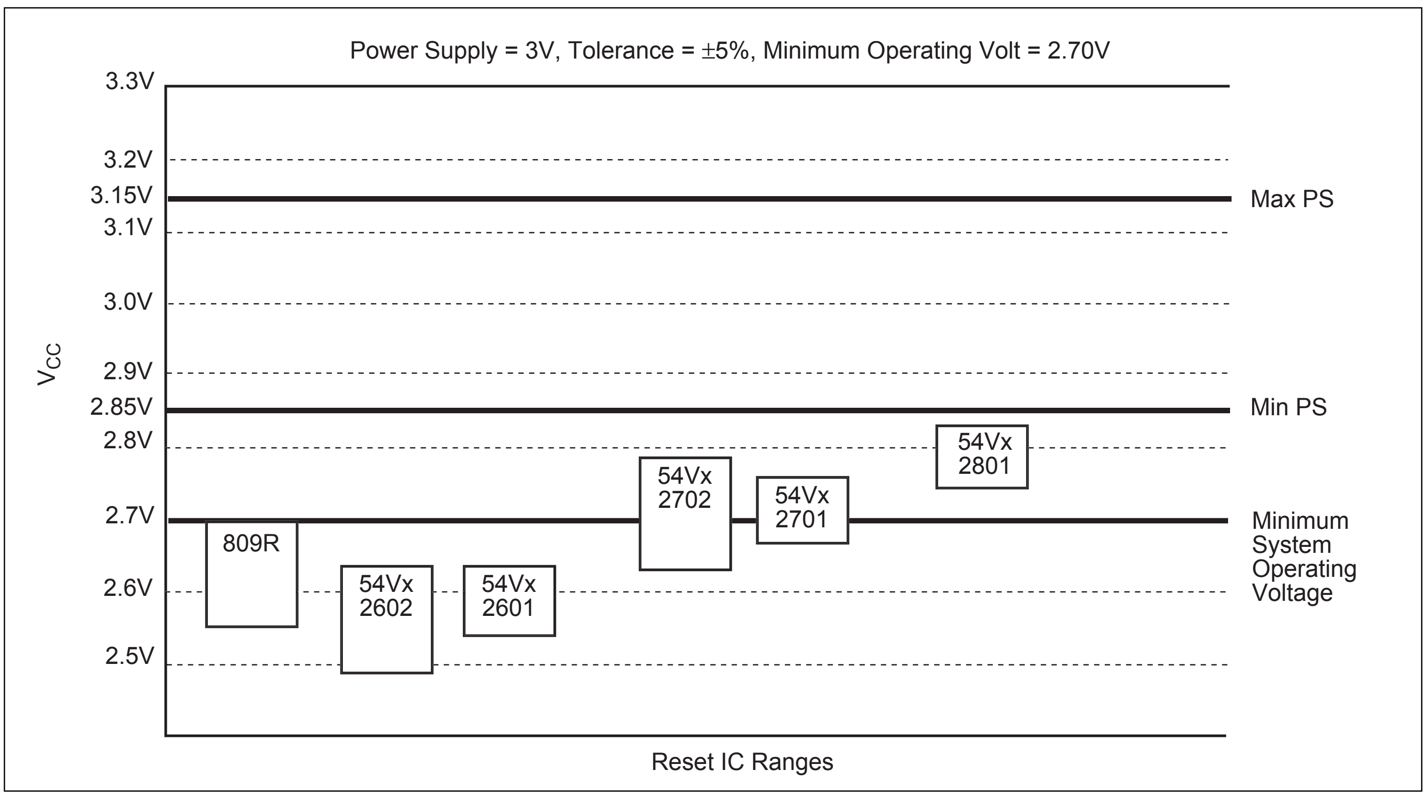

FIGURE 7: *Ideal situation.*

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