

Simultaneous power-down sequencing with the TPS74x01 family of linear regulators

By Jeff Falin

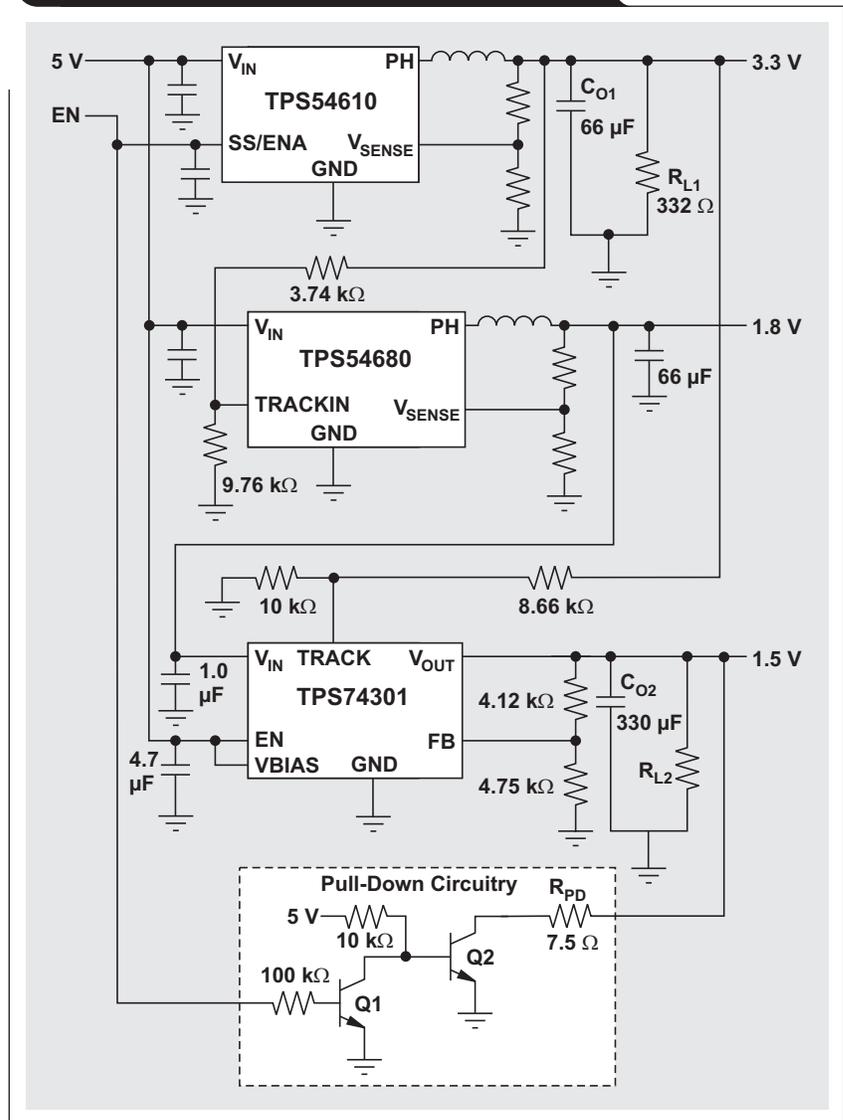
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Introduction

In the past, ensuring successful power up for DSPs and FPGAs in electronic equipment was a challenge. The most recent DSPs and FPGAs have more relaxed requirements for core and I/O power up/down. However, a few still specify power-up ramp rates and recommend sequential sequencing for predictable and repeatable startup. Even fewer specify power-down requirements, including ramp rates and/or sequences. In most cases, the ultimate goal of these requirements is to ensure that the DSP and FPGA power rails do not have a larger differential voltage than that for which they were designed, even during the brief periods at power up/down. Otherwise, immediate or cumulative damage to internal circuits, which reduces long-term reliability, can occur. Therefore, the ideal method for DSP and FPGA power up/down is for all rails to rise and fall at the same time and rate.

Two or more power-rail ICs are said to have been simultaneously sequenced on power up when they track one another with the same rising dv/dt , and the lower rail stops at its regulated voltage while the upper rail continues to its higher regulated voltage. Various devices, including the TPS74301 linear regulator, have a tracking input to provide simultaneous power-up sequencing. Simultaneous sequencing on power up/down is implemented by replacing the converter's error-amplifier reference voltage with the tracking input signal while the signal is less than the reference voltage. However, for power-down sequencing to work, the converter must have circuitry to pull down the output under light load. Switching converters such as the TPS54x80 family can easily pull down the output by modulating the duty cycle. Most linear regulators do not have pull-down circuitry; so, even though the linear regulator tries to lower the output voltage, it must wait for the output

Figure 1. Block diagram of TPS74301 providing power-up/down sequencing



capacitor to discharge through the load resistance. Figure 1 shows a block diagram of the TPS74301 configured to track the 3.3-V rail from a TPS54610. See Reference 1 for a complete schematic of TPS54xxx devices.

Figure 2 shows simultaneous power up of the 3.3-V and 1.5-V rails. Figure 3 shows that, with the pull-down circuitry (low-cost, bipolar transistors Q1 and Q2 and their supporting components) removed, the TPS74301 output voltage does not track down because the power-down load resistance is too high. The pull-down circuitry shown in

Figure 1 adds the pull-down resistor, R_{PD} , in parallel with R_{L2} , which lowers the regulator's load resistance and its RC time constant ($R_{L2} \times C_{O2}$) during power down. This means that the TPS74301 output will track down as shown in Figure 4, since the $R_{PD} \parallel (R_{L2} \times C_{O2})$ time constant is less than the $R_{L1} \times C_{O1}$ time constant.

Figure 2. TPS74301 1.5-V output with power-up sequencing

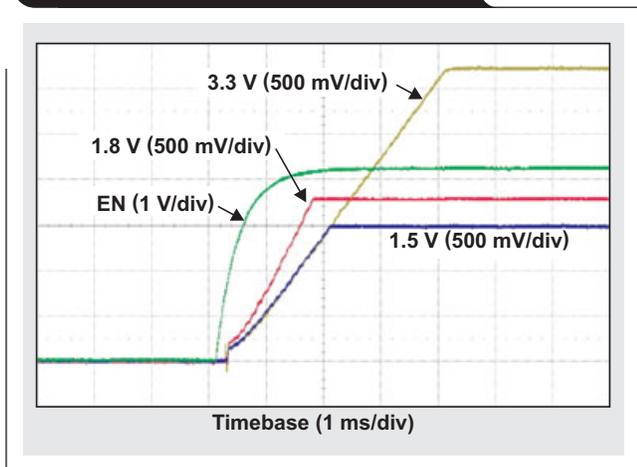


Figure 3. TPS74301 1.5-V output without power-down sequencing

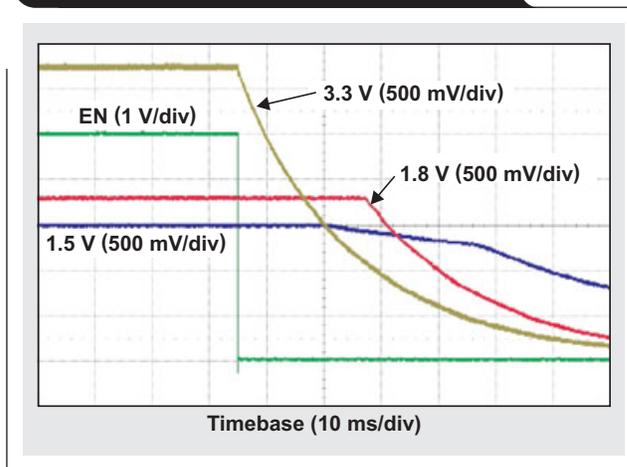
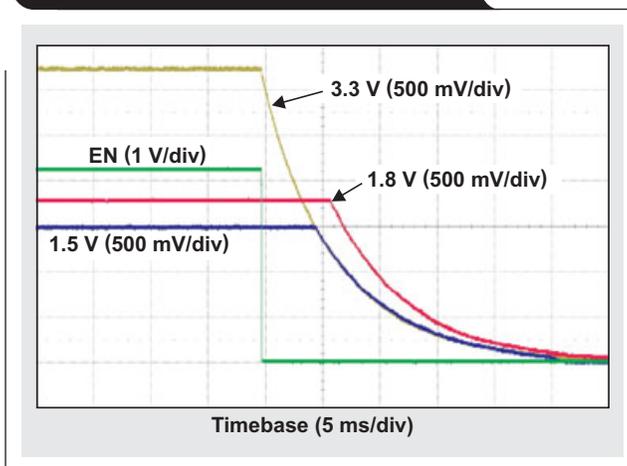


Figure 4. TPS74301 1.5-V output with power-down sequencing



The circuit in Figure 5 shows how to make all versions of the TPS74x01 family achieve “pseudo” simultaneous power-up/down sequencing by having V_{OUT} follow V_{IN} . When V_{IN} is less than the sum of the output voltage and the regulator’s dropout voltage (V_{DO}) for a given output load, the regulator’s pass element is operating in dropout. Therefore, if the load during power up/down is heavy enough, the regulator’s output voltage could be below the voltage being tracked by $V_{DO(max)}$. Note that the soft-start capacitor, C_{SS} , must be set so that the TPS74x01 output ramps up faster than V_{IN} .

Figures 6 and 7 show power-up/down sequencing using the nontracking TPS74801 and TPS74201, respectively, with a 1.5-A output load and $V_{OUT} = 1.5$ V. Since the TPS74801 has a higher dropout than the TPS74201, the difference between $V_{OUT} = 1.5$ V and $V_{IN} = 1.8$ V is more noticeable in Figure 6 than in Figure 7. Figures 8 and 9 show the same results but with no load connected to the output and with $V_{OUT} = 1.5$ V. Notice in Figures 8b and 9b that on power down the output voltage stays high for a brief time (creating a ledge of sorts) until the pass element’s reverse diode turns on to assist in discharging the output capacitance.

Figure 5. Block diagram of TPS74x01 providing pseudo power-up/down sequencing

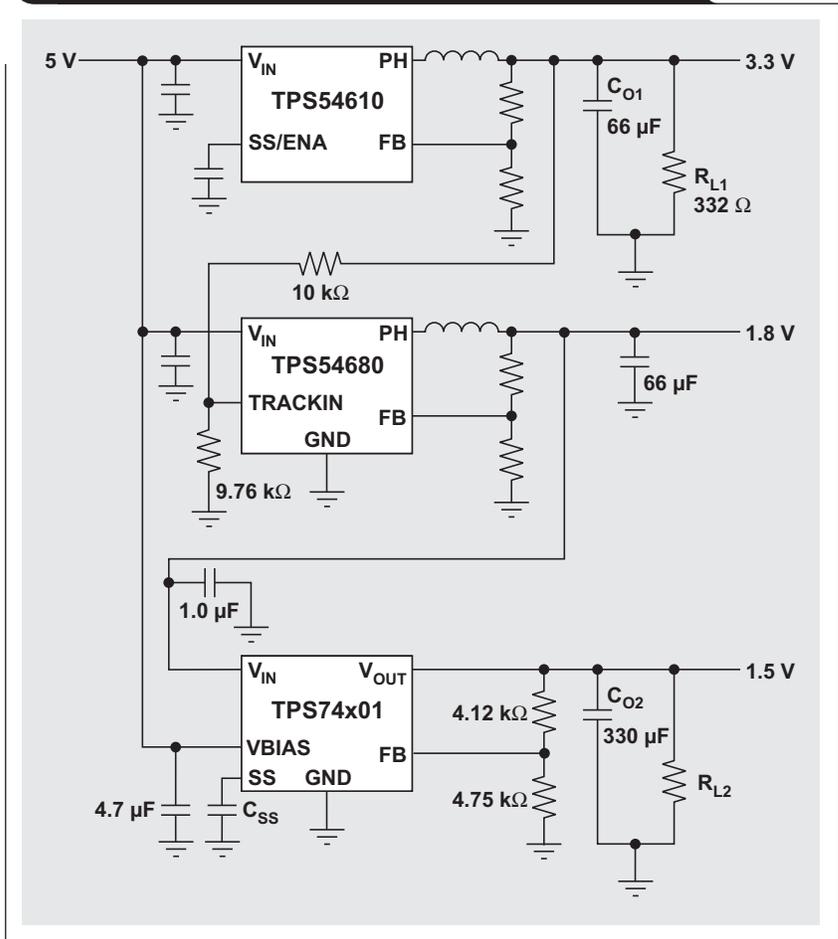
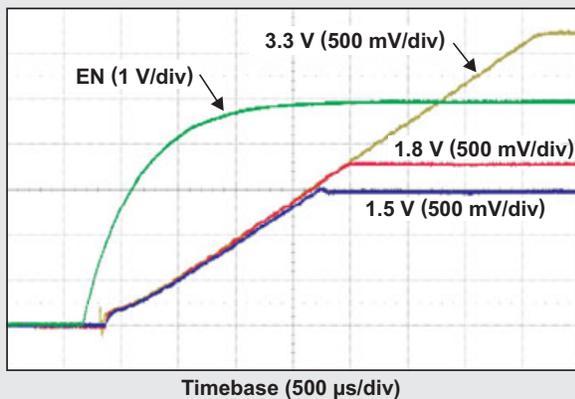
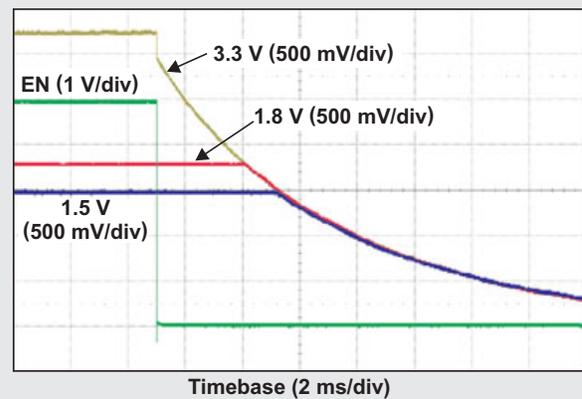


Figure 6. TPS74801 1.5-V output with $R_{L2} = 1 \Omega$

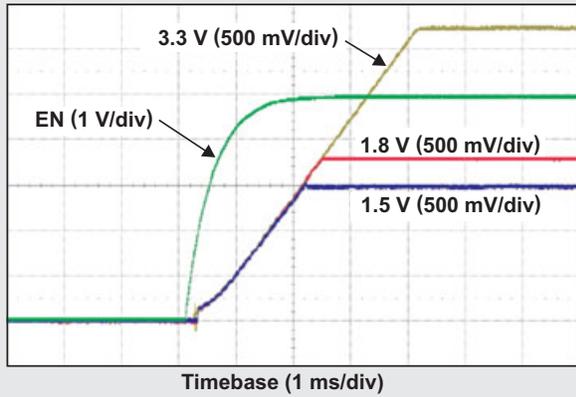


(a) Pseudo power-up sequencing with V_{IN} connected to 1.8-V output

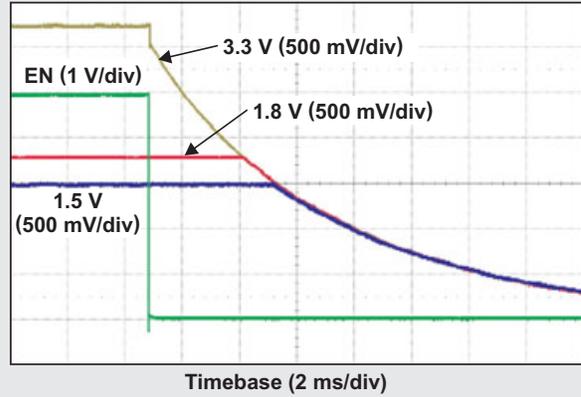


(b) Pseudo power-down sequencing with V_{IN} connected to 1.8-V output

Figure 7. TPS74201 1.5-V output with $R_{L2} = 1 \Omega$

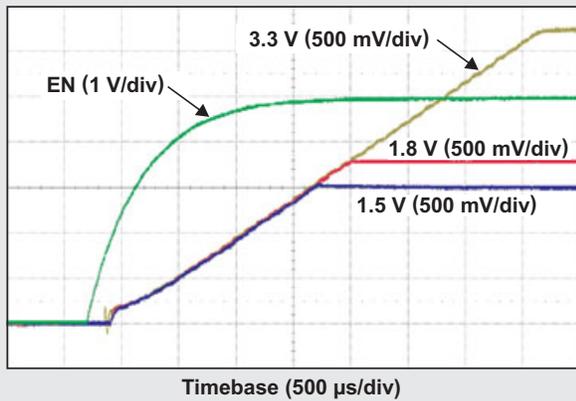


(a) Pseudo power-up sequencing with V_{IN} connected to 1.8-V output

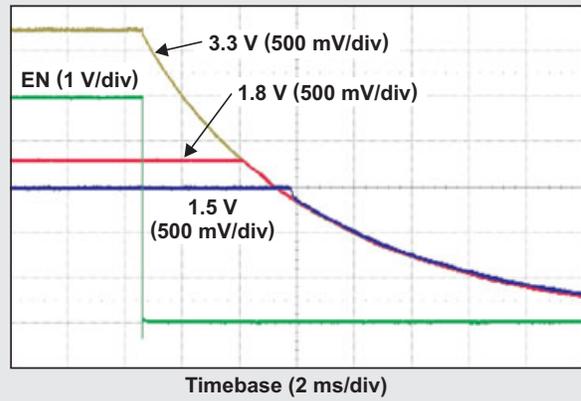


(b) Pseudo power-down sequencing with V_{IN} connected to 1.8-V output

Figure 8. TPS74801 1.5-V output with no load

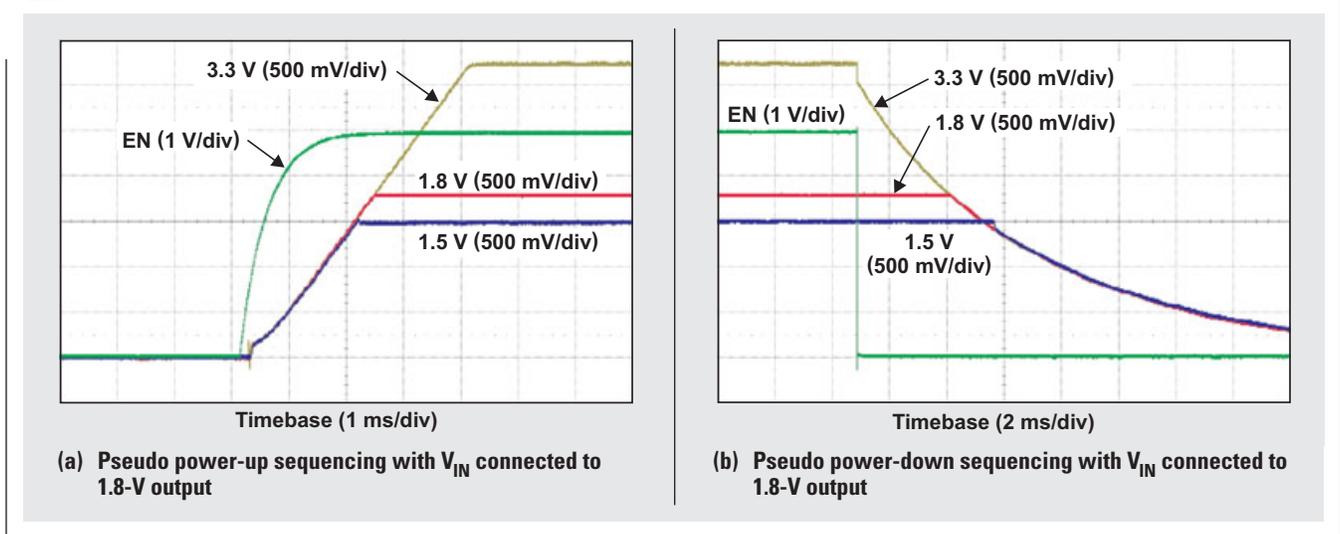


(a) Pseudo power-up sequencing with V_{IN} connected to 1.8-V output



(b) Pseudo power-down sequencing with V_{IN} connected to 1.8-V output

Figure 9. TPS74201 1.5-V output with no load



Conclusion

To meet DSP and FPGA power-on requirements, many new DC/DC converters provide methods for controlling startup. Some also have integrated features to assist with those few DSPs and FPGAs that have power-down requirements. The TPS74x01 family of linear regulators easily provides simultaneous power-up sequencing and, with the assistance of simple pull-down circuitry and/or careful sizing of the load resistance at power down, provides two different methods for achieving simultaneous power-down sequencing.

Reference

For more information related to this article, you can download an Acrobat Reader file at www-s.ti.com/sc/techlit/litnumber and replace "litnumber" with the **TI Lit. #** for the materials listed below.

Document Title

TI Lit. #

1. "TPS54680EVM-228 6-Amp, TPS54880EVM-228 8-Amp, SWIFT™ Regulator Evaluation Module," User's Guide . . .slvu077

Related Web sites

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Replace *partnumber* with TPS54610, TPS54680, TPS74201, TPS74301, or TPS74801

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