

Understanding TPS61175's Pulse-Skipping Function

Sanjay Pithadia and Jeff Falin

PMP - DC/DC Controllers

ABSTRACT

This application report explains how TPS61175 behaves in Pulse-Skipping mode and how the frequency of the pulse skipping varies with change in different components.

Pulse-Skipping Mode of TPS61175

The TPS61175 is 3A high voltage boost converter with soft start and programmable switching frequency. The TPS61175 regulates the output voltage with current mode pulse width modulation (PWM) control. Once the PWM switch is turned on, the TPS61175 has minimum ON pulse width of 60-ns. This sets the limit of the minimum duty cycle of the PWM switch, and it is independent of the set switching frequency. As the output current drops, the boost converter enters discontinuous conduction mode (DCM). In DCM, the on time is a function of load current. If a very light load current only requires the switch on time to be less than 60 ns typical (110 ns maximum), the IC enters pulse-skipping mode. In this mode, the device prevents the switch from turning on for one or more switching cycles to prevent the output voltage from rising above the regulated voltage. Compared to normal PWM operation, the output ripple in pulse skipping will be larger.

In a device without pulse skipping, the PWM cycle starts at the rising edge of the clock whenever the PWM comparator output is low. The PWM cycle ends when PWM comparator output goes high. (see cycles T1, T2 and T4 in [Figure 1](#)).

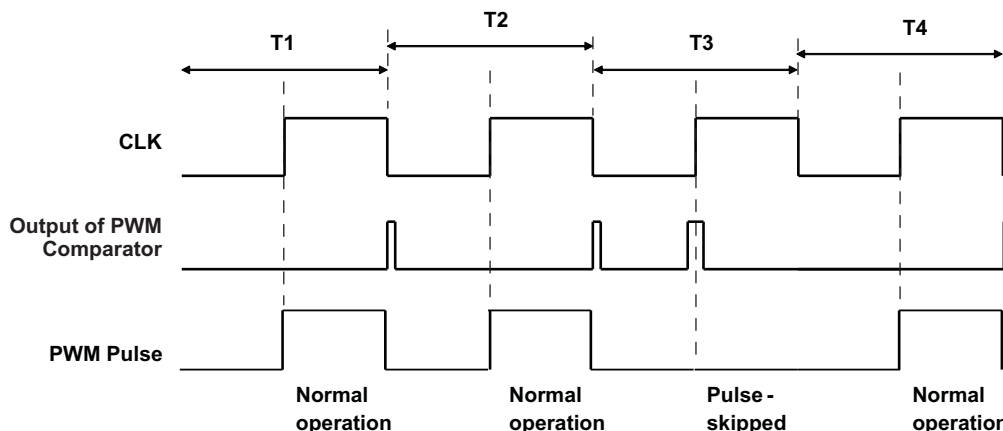


Figure 1. Operation of TPS61175

The TPS61175's pulse skip circuitry operates by checking the output of the PWM comparator just before the CLK rising edge. If the PWM comparator output is high at this moment then one cycle (or pulse) is skipped. The exact relationship between pulse skip frequency and load current is a complex function of L, Co, Vin, Vo and the control loop. Since one input to the PWM comparator is the output of the error amplifier (i.e., the IC's COMP pin), changing the compensation components changes not only the time between switching bursts in pulse skip mode (i.e. the pulse skip frequency) but also the number of pulses within each burst. Specifically, the pulse skipping frequency, f_{PS} varies inversely with the compensation capacitance value and directly with the compensation resistance value. In other words, f_{PS} varies directly with the loop bandwidth of the converter.

[Submit Documentation Feedback](#)

Table 1. Waveform Legend (continued)

Channel	Corresponding Waveform	Vertical Scale	Time Scale
Channel 2 (Red)	AC-coupled output voltage waveform	200 mV/div	1 ms/div
Channel 3 (Blue)	Voltage waveform on COMP pin	200 mV/div	1 ms/div
Channel 4 (Green)	Load Current waveform	200 mA/div	1 ms/div

1. For Output current = 220 μ A

a. $R3 = 3.09 \text{ k}\Omega$, $C4 = 33 \text{ nF} \rightarrow f_{PS} \approx 599.91 \text{ Hz}$

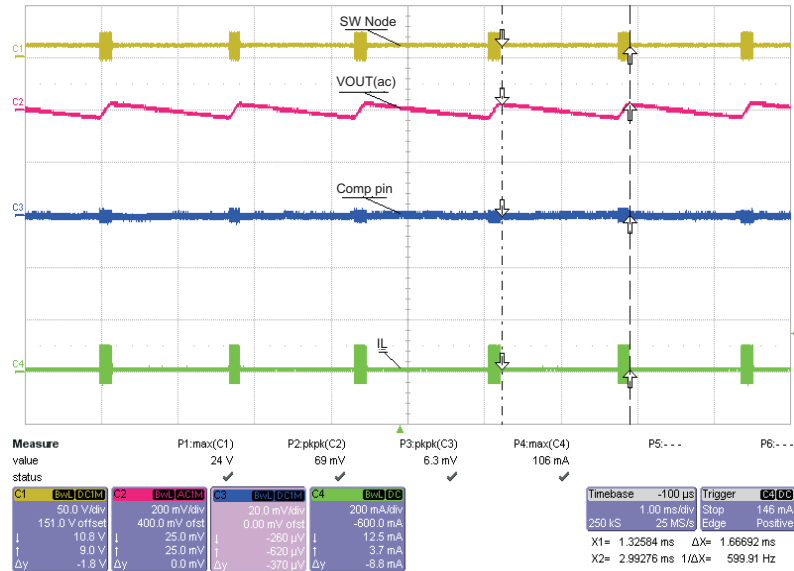


Figure 3. Test Condition 1(a)

b. Same $R3 = 3.09 \text{ k}\Omega$, larger $C4 = 68 \text{ nF}$, lower loop crossover \rightarrow lower $f_{PS} = 755.171 \text{ Hz}$

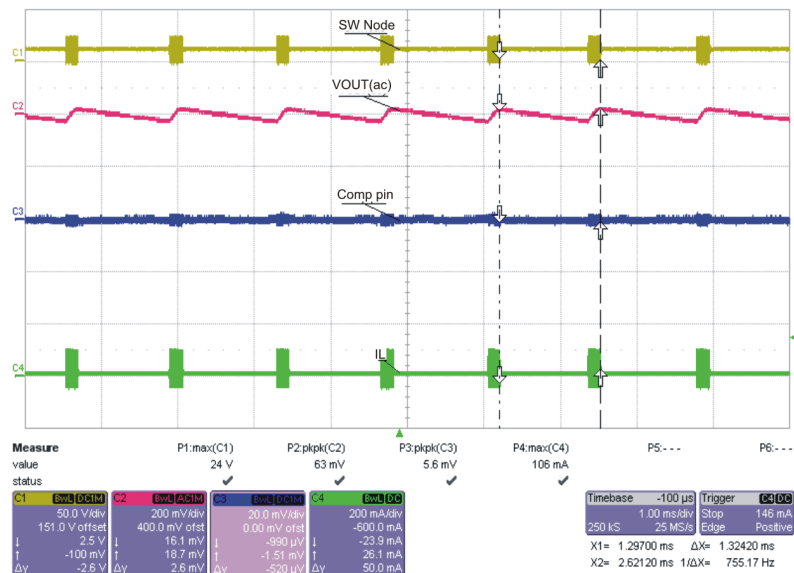


Figure 4. Test Condition 1(b)

c. Smaller $R3 = 1 \text{ k}\Omega$, same $C4 = 33 \text{ nF}$, lower loop crossover \rightarrow lower $f_{PS} = 314.039 \text{ Hz}$

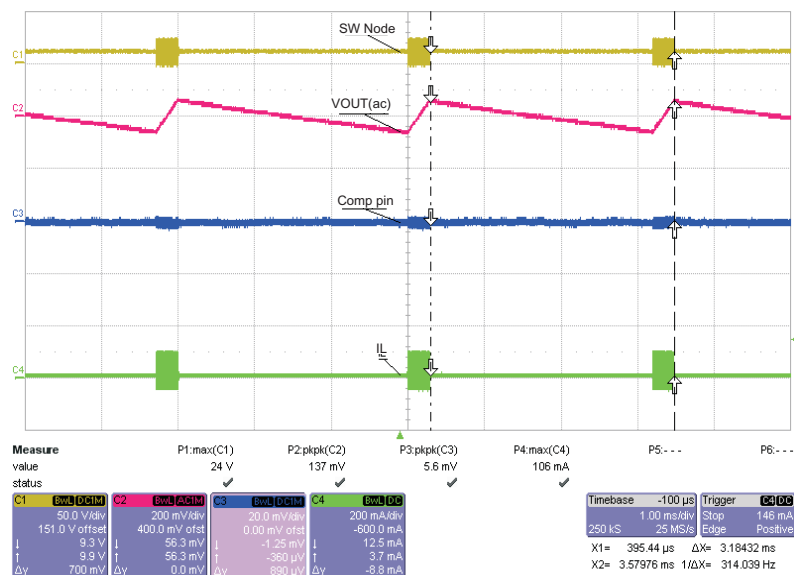


Figure 5. Test Condition 1(c)

2. For Output current = 110 μA

a. $R3 = 3.09 \text{ k}\Omega$, $C4 = 33 \text{ nF} \rightarrow f_{PS} = 340.532 \text{ Hz}$

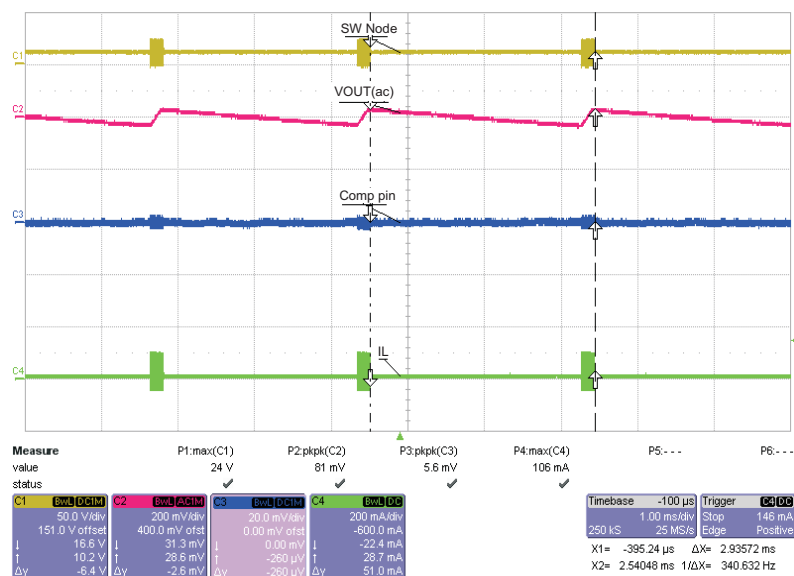


Figure 6. Test Condition 2(a)

b. Same $R3 = 3.09 \text{ k}\Omega$, larger $C4 = 68 \text{ nF}$, lower loop cross over \rightarrow slower $f_{PS} = 533.15 \text{ Hz}$

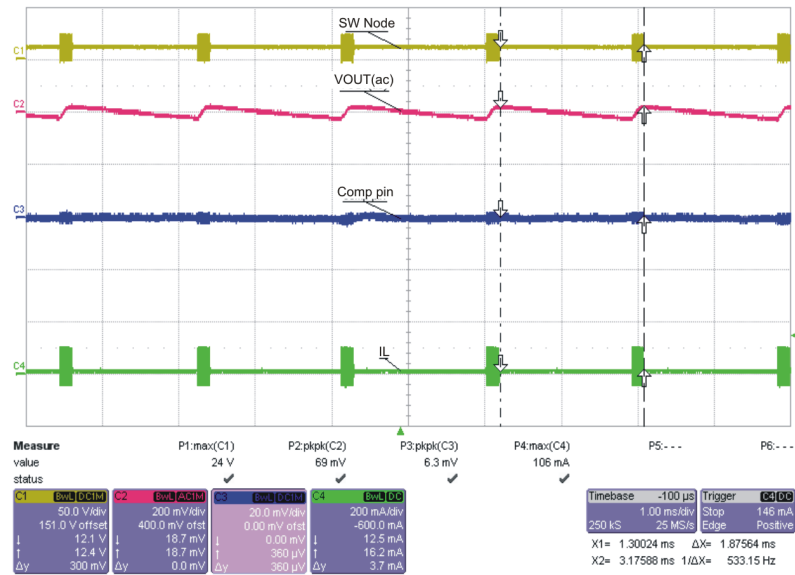


Figure 7. Test Condition 2(b)

c. Smaller R3 = 1 kΩ, same C4 = 33 nF, lower loop crossover → lower $f_{PS} = 230.352$ Hz

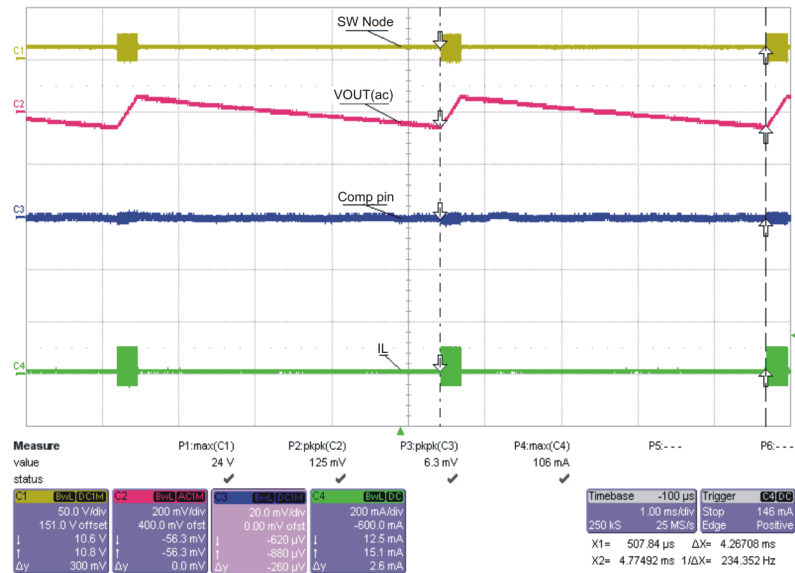


Figure 8. Test Condition 2(c)

Conclusion

The TPS61175 pulse skipping feature operates by simply blanking out the clock pulse, thereby not turning on the FET, if the PWM comparator output is high at the beginning of each clock cycle. The skip cycle threshold can be found using the on time equation in DCM mode; however, the frequency between pulse skip operation bursts varies inversely with the compensation capacitance value and directly with the compensation resistance value. In other words, it varies directly with the loop bandwidth of the converter.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
RF/IF and ZigBee® Solutions	www.ti.com/lpr

Applications

Audio	www.ti.com/audio
Automotive	www.ti.com/automotive
Broadband	www.ti.com/broadband
Digital Control	www.ti.com/digitalcontrol
Medical	www.ti.com/medical
Military	www.ti.com/military
Optical Networking	www.ti.com/opticalnetwork
Security	www.ti.com/security
Telephony	www.ti.com/telephony
Video & Imaging	www.ti.com/video
Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2009, Texas Instruments Incorporated