

# TPS40190 4.5-V to 15-V Input, Voltage-Mode, Synchronous Buck Controller

## 1 Features

- Input Operating Voltage Range: 4.5 V to 15 V
- Reference 0.591 V  $\pm 1\%$
- Voltage Mode Control
- Internal 5-V Regulator For Internal Housekeeping, Driver Power and Light External Loads
- Selectable Short-Circuit Protection Thresholds
- Pre-Bias Output Safe
- Fixed Switching Frequency of 300 kHz
- Internal Soft Start
- Small 3 mm  $\times$  3 mm, 10-Pin SON Package
- Bootstrapped Drivers for N-Channel MOSFET
- Adaptive Anti-Cross Conduction
- Internal Bootstrap Diode
- 1.2-A Drivers for Decreased Switching Loss

## 2 Applications

- Cable modem CPE
- Digital Set Top Box
- Graphics/Audio Cards
- Entry-level and Mid-Range Servers

## 3 Description

The TPS40190 is a cost-optimized synchronous buck controller that operates from 4.5 V to 15 V nominally, and implements a fixed frequency voltage mode power supply. The controller uses an adaptive anti-cross conduction scheme to prevent both the high-side and the rectifier MOSFET to be turned on at the same time, preventing shoot through current in the two MOSFETs.

The controller also provides a short circuit protection threshold that is user selectable between one of three values. The protection level is set with a single external resistor connected from COMP to GND. During start-up, the impedance connected to COMP is sensed, and the information is decoded to select one of the three thresholds. When the controller senses an output short circuit, both MOSFETs are turned off and a timeout period is observed before attempting to restart. This provides limited power dissipation in the event of a sustained fault.

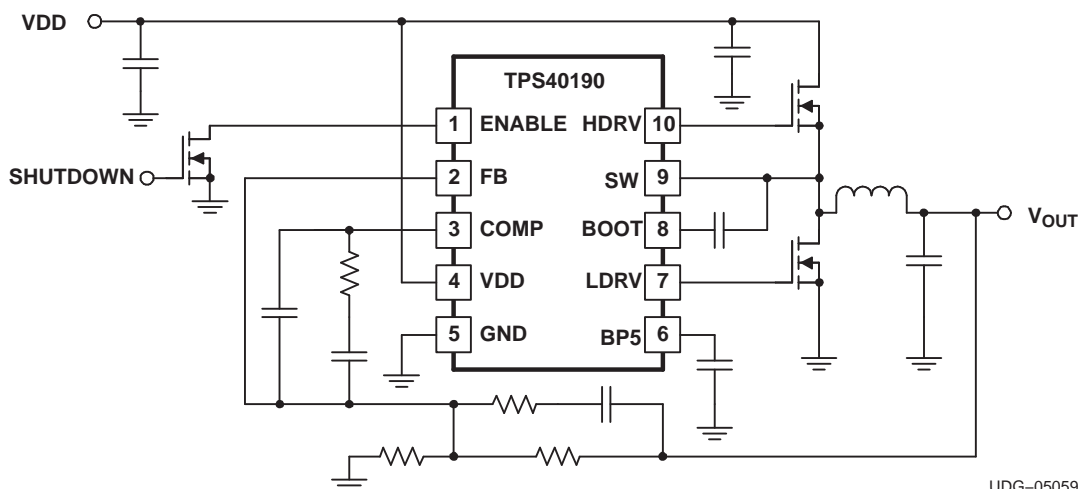
The TPS40190 provides strong drivers to minimize switching losses in the power stage, reducing heat build up in the MOSFETs and allowing larger MOSFETs to be used without undue switching time penalty.

### Device Information<sup>(1)</sup>

| PART NUMBER | PACKAGE   | BODY SIZE (NOM)          |
|-------------|-----------|--------------------------|
| TPS40190    | VSON (10) | 3.00 mm $\times$ 3.00 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

### Simplified Application Diagram



UDG-05059



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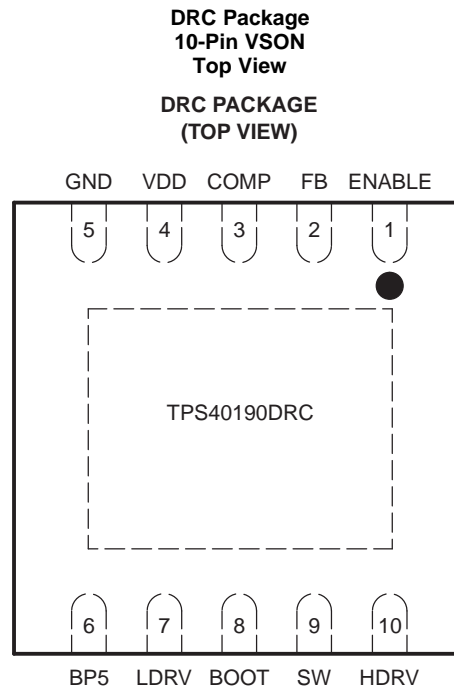
## 4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Revision C (July 2012) to Revision D  | Page     |
|--|----------|
| • Editorial changes only, no technical revisions .....   | <b>1</b> |
| • Added <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section ..... | <b>1</b> |
| • Deleted Ordering Information table .....   | <b>3</b> |

| Changes from Revision B (August 2007) to Revision C                          | Page      |
|--|-----------|
| • Added a new paragraph to the end of the Enable Functionality section ..... | <b>14</b> |

## 5 Pin Configuration and Functions



### Pin Functions

| PIN |        | I/O | DESCRIPTION   |
|-----|--------|-----|---|
| NO. | NAME   |     |   |
| 1   | ENABLE | I   | Logic level input that starts or stops the controller from an external user command. A high level turns the controller on. This pin has a high-impedance internal pull-up integrated into the device. Because this pin is high impedance, a 10-nF capacitor to ground or an external pull-up resistor (100 kΩ) to VDD is recommended to avoid noise coupling to this pin. |
| 2   | FB     | I   | Inverting input to the error amplifier  |
| 3   | COMP   | O   | Output of the error amplifier. Connecting a resistance from COMP to GND sets the output short circuit detection threshold. See applications information for details.  |
| 4   | VDD    | I   | Power input to the controller   |
| 5   | GND    | —   | Common connection for the controller  |
| 6   | BP5    | O   | Output bypass for the internal regulator. Connect 4.7-μF capacitor from this pin to GND. Low power, low noise loads may be connected here if desired. The sum of the external load and the gate drive requirements must not exceed 40 mA. The regulator is turned off when the ENABLE pin is pulled low.  |
| 7   | LDRV   | O   | Output to the rectifier FET gate  |
| 8   | BOOT   | I   | Power supply for the flying high-side driver  |
| 9   | SW     | I   | Sense line for the adaptive anti cross conduction circuitry. Serves as common connection for the flying high side FET driver  |
| 10  | HDRV   | O   | Bootstrapped output for driving the gate of the high side N channel FET.  |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|  |  | MIN  | MAX  | UNIT |
|--|--|------|------|------|
| Input voltage range                            | VDD  | −0.3 | 16.5 | V    |
|  | SW   | −5   | 22   |      |
|  | BOOT-SW, HDRV-SW<br>(differential from BOOT or HDRV to SW) | −0.3 | 6    |      |
|  | COMP   | −0.3 | 3    |      |
|  | FB, BP5, LDRV, ENABLE                                      | −0.3 | 6    |      |
| Operating junction temperature, T <sub>J</sub> |  | −40  | 125  | °C   |
| Storage temperature, T <sub>stg</sub>          |  | −55  | 150  | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

### 6.2 Dissipation Ratings

| PACKAGE | R <sub>θJA</sub> High-K Board <sup>(1)</sup><br>(°C/W) | R <sub>θJC</sub> <sup>(2)</sup><br>(°C/W) |
|---------|--|---|
| DRC     | 47.9   | 14.1                                      |

- (1) The JEDEC High-K (2s2p) board design used to derive this data was a 3-inch x 3-inch (7.5-cm x 7.5-cm), multilayer board with one-ounce internal power and ground planes and two-ounce copper traces on top and bottom of the board.
- (2) The junction-to-case impedance is measured from the die to the thermal pad on the device package.

### 6.3 Recommended Operating Conditions

|                 |                                | MIN | NOM | MAX | UNIT |
|-----------------|--------------------------------|-----|-----|-----|------|
| V <sub>DD</sub> | Input voltage                  | 4.5 |     | 15  | V    |
| T <sub>A</sub>  | Operating free-air temperature | −40 |     | 85  | °C   |

## 6.4 Electrical Characteristics

$T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ ,  $V_{DD} = 12\text{ V}_{dc}$ ,  $T_A = T_J$ , and all parameters at zero power dissipation (unless otherwise noted)

| PARAMETER                |   | TEST CONDITIONS  | MIN | TYP  | MAX  | UNIT |
|--------------------------|---|--|-----|------|------|------|
| V <sub>FB</sub>          | Feedback voltage range                            | 0°C ≤ T <sub>J</sub> ≤ 85°C  | 585 | 591  | 597  | mV   |
|                          |   | -40°C ≤ T <sub>J</sub> ≤ 85°C  | 582 | 591  | 597  |      |
| INPUT SUPPLY             |   |  |     |      |      |      |
| V <sub>VDD</sub>         | Input voltage range                               |  | 4.5 |      | 15.0 | V    |
| I <sub>VDD</sub>         | Operating current                                 | V <sub>ENABLE</sub> = 2.5 V, Outputs switching   |     |      | 2.5  | mA   |
|                          |   | V <sub>ENABLE</sub> = 0.6 V  |     |      | 20   | μA   |
| ON BOARD REGULATOR       |   |  |     |      |      |      |
| V <sub>5VBP</sub>        | Output voltage                                    | V <sub>VDD</sub> > 6 V, I <sub>5VBP</sub> ≤ 10 mA                                      | 5.1 | 5.3  | 5.5  | V    |
| V <sub>DO</sub>          | Regulator dropout voltage                         | V <sub>VDD</sub> - V <sub>BP5</sub> , V <sub>VDD</sub> = 5 V, I <sub>BP5</sub> ≤ 25 mA |     | 270  | 400  | mV   |
| I <sub>SC</sub>          | Regulator current limit threshold                 |  | 40  |      |      | mA   |
| I <sub>BP5</sub>         | Average current <sup>(1)</sup>                    |  |     |      | 40   |      |
| OSCILLATOR               |   |  |     |      |      |      |
| f <sub>SW</sub>          | Switching frequency                               |  | 240 | 300  | 360  | kHz  |
| V <sub>RMP</sub>         | Ramp amplitude <sup>(2)</sup>                     |  |     | 0.75 |      | V    |
| V <sub>VALLEY</sub>      | Valley voltage <sup>(2)</sup>                     |  |     | 0.5  |      | V    |
| PWM                      |   |  |     |      |      |      |
| D <sub>MAX</sub>         | Maximum duty cycle <sup>(2)</sup>                 |  | 85% |      |      |      |
| t <sub>ON(min)</sub>     | Minimum controlled pulse <sup>(2)</sup>           |  |     |      | 130  | ns   |
| t <sub>DEAD</sub>        | Output driver dead time                           | HDRV off to LDRV on  |     | 50   |      | ns   |
|                          |   | LDRV off to HDRV on  |     | 25   |      |      |
| SOFT-START               |   |  |     |      |      |      |
| t <sub>SS</sub>          | Soft-start time                                   |  | 3.0 | 4.7  | 7.0  | ms   |
| t <sub>SSDLY</sub>       | Soft-start delay time <sup>(3)</sup>              |  |     | 6    |      | ms   |
| t <sub>REG</sub>         | Time to regulation                                |  |     | 10.5 |      | ms   |
| ERROR AMPLIFIER          |   |  |     |      |      |      |
| GBWP                     | Gain bandwidth product <sup>(2)</sup>             |  | 5   |      |      | MHz  |
| A <sub>OL</sub>          | DC gain <sup>(2)</sup>                            |  | 60  |      |      | dB   |
| I <sub>IB</sub>          | Input bias current (current out of FB pin)        |  | 100 |      | 0    | nA   |
| I <sub>EAOP</sub>        | Output source current                             | V <sub>FB</sub> = 0 V  | 1   |      |      | mA   |
| I <sub>EAOM</sub>        | Output sink current                               | V <sub>FB</sub> = 2 V  | 1   |      |      | mA   |
| SHORT CIRCUIT PROTECTION |   |  |     |      |      |      |
| t <sub>PSS(min)</sub>    | Minimum pulse during short circuit <sup>(2)</sup> |  |     |      | 250  | ns   |
| t <sub>BLNK</sub>        | Blanking time <sup>(2)</sup>                      |  | 100 | 140  | 180  | ns   |
| t <sub>OFF</sub>         | Off-time between restart attempts                 |  | 25  | 95   |      | ms   |
| V <sub>ILIM</sub>        | Short circuit comparator threshold voltage        | R <sub>COMP(GND)</sub> = OPEN, T <sub>J</sub> = 25°C                                   | 256 | 320  | 384  | mV   |
|                          |   | R <sub>COMP(GND)</sub> = 4 kΩ, T <sub>J</sub> = 25°C                                   | 128 | 160  | 192  |      |
|                          |   | R <sub>COMP(GND)</sub> = 12 kΩ, T <sub>J</sub> = 25°C                                  | 368 | 460  | 552  |      |

(1) 40 mA is the current available for MOSFET gate drive, the device itself and any external loads. The sum of these must not exceed 40 mA.

(2) Specified by design. Not production tested.

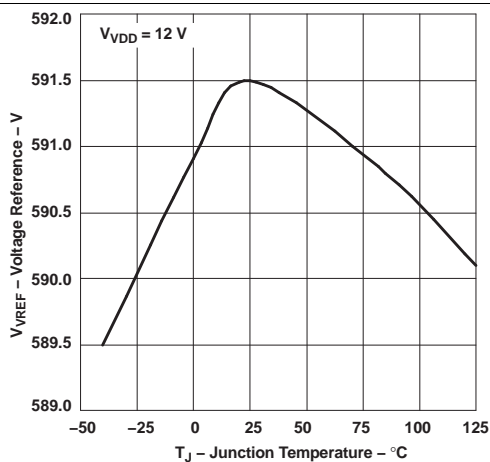
(3) The delay time is the time delay from application of power to the device or from assertion of ENABLE until the output begins to rise.

## Electrical Characteristics (continued)

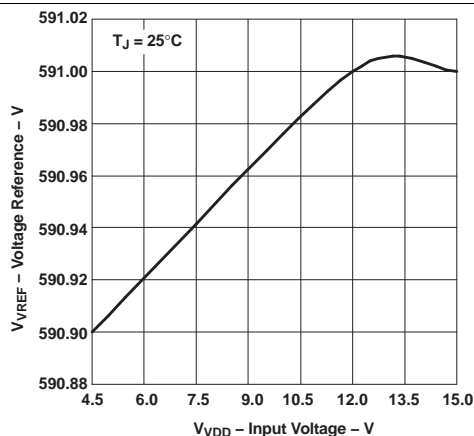
$T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ ,  $V_{DD} = 12\text{ V}_{dc}$ ,  $T_A = T_J$ , and all parameters at zero power dissipation (unless otherwise noted)

| PARAMETER                          |   | TEST CONDITIONS  | MIN | TYP  | MAX | UNIT     |
|------------------------------------|---|--|-----|------|-----|----------|
| <b>OUTPUT DRIVERS</b>              |   |  |     |      |     |          |
| $R_{HDI}$                          | High-side driver pull-up resistance       | $V_{BOOT} - V_{SW} = 4.5\text{ V}$ , $I_{HDRV} = -100\text{ mA}$ |     | 3    | 6   | $\Omega$ |
| $R_{HDO}$                          | High-side driver pull-down resistance     | $V_{BOOT} - V_{SW} = 4.5\text{ V}$ , $I_{HDRV} = 100\text{ mA}$  |     | 1.5  | 3   | $\Omega$ |
| $R_{LDI}$                          | Low-side driver pull-up resistance        | $I_{LDRV} = -100\text{ mA}$                                      |     | 2.5  | 5   | $\Omega$ |
| $R_{LDO}$                          | Low-side driver pull-down resistance      | $I_{LDRV} = 100\text{ mA}$                                       |     | 0.8  | 1.5 | $\Omega$ |
| $t_{HRISE}$                        | High-side driver rise time <sup>(2)</sup> | $C_{LOAD} = 1\text{ nF}$   |     | 15   | 35  | ns       |
| $t_{HFAIL}$                        | High-side driver fall time <sup>(2)</sup> | $C_{LOAD} = 1\text{ nF}$   |     | 10   | 25  | ns       |
| $t_{LRISE}$                        | Low-side driver rise time <sup>(2)</sup>  | $C_{LOAD} = 1\text{ nF}$   |     | 15   | 35  | ns       |
| $t_{LFAIL}$                        | Low-side driver fall time <sup>(2)</sup>  | $C_{LOAD} = 1\text{ nF}$   |     | 10   | 25  | ns       |
| <b>UNDERVOLTAGE LOCKOUT (UVLO)</b> |   |  |     |      |     |          |
| $V_{UVLO}$                         | Turn-on voltage                           |  | 4.1 | 4.25 | 4.4 | V        |
| $UVLO_{HYST}$                      | Hysteresis                                |  | 270 | 320  | 370 | mV       |
| <b>SHUTDOWN</b>                    |   |  |     |      |     |          |
| $V_{IH}$                           | High-level input voltage                  | ENABLE   |     |      | 2.8 | V        |
| $V_{IL}$                           | Low-level input voltage                   | ENABLE   | 0.6 |      |     | V        |
| <b>BOOT DIODE</b>                  |   |  |     |      |     |          |
| $V_{DFWD}$                         | Bootstrap diode forward voltage           | $I_{BOOT} = 5\text{ mA}$   | 0.6 | 0.8  | 1.2 | V        |

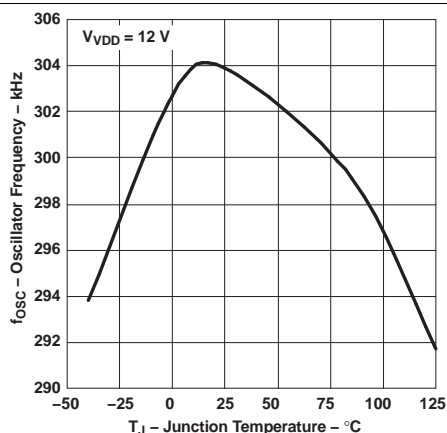
## 6.5 Typical Characteristics



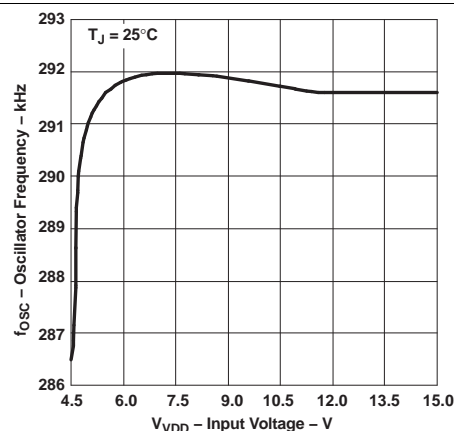
**Figure 1. Reference Voltage vs Temperature**



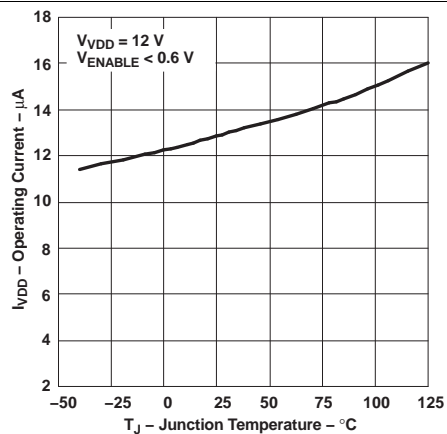
**Figure 2. Reference Voltage vs Input Voltage**



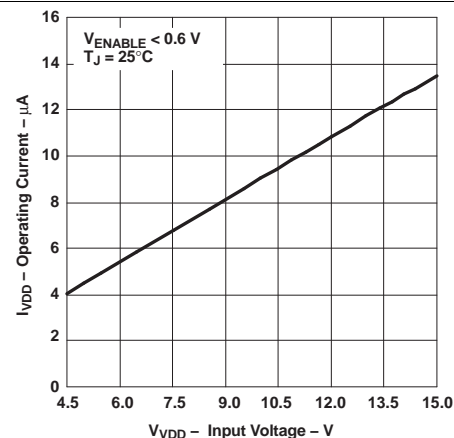
**Figure 3. Oscillator Frequency vs Temperature**



**Figure 4. Oscillator Frequency vs Input Voltage**



**Figure 5. Operating Current vs Temperature**



**Figure 6. Operating Current vs Input Voltage**

## Typical Characteristics (continued)

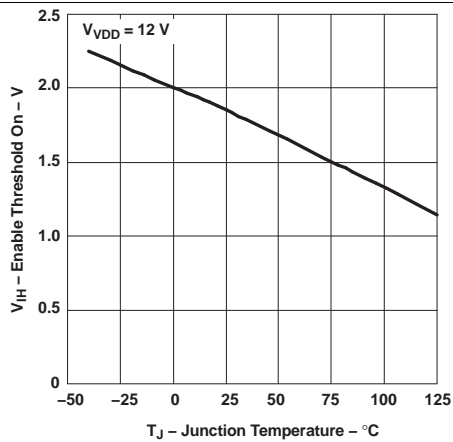


Figure 7. Enable Threshold On vs Temperature

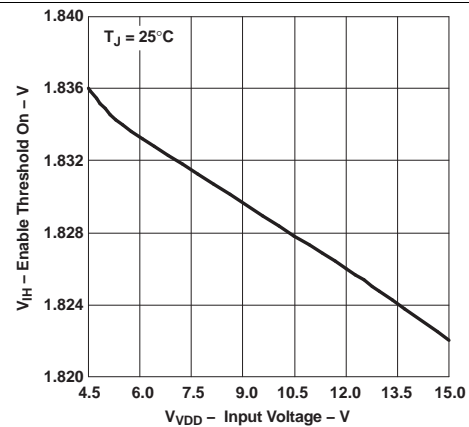


Figure 8. Enable Threshold On vs Input Voltage

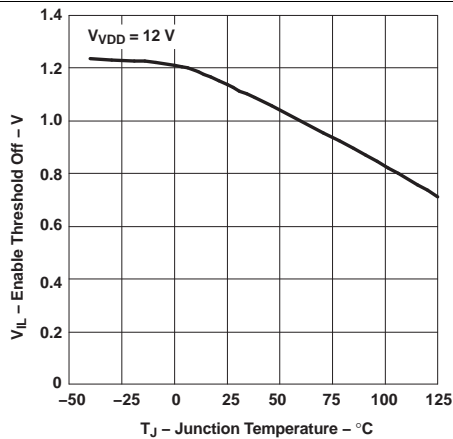


Figure 9. Enable Threshold Off vs Temperature

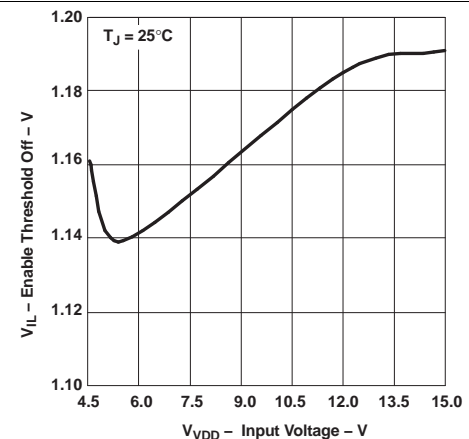


Figure 10. Enable Threshold Off vs Input Voltage

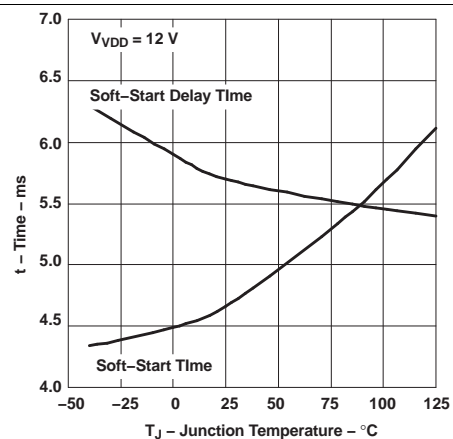


Figure 11. Soft Start Timing vs Temperature

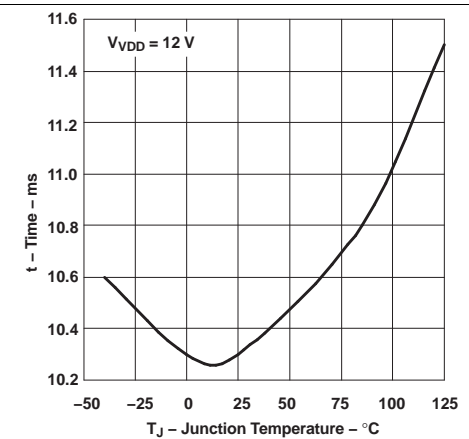


Figure 12. Total Startup Time vs Temperature



## Typical Characteristics (continued)

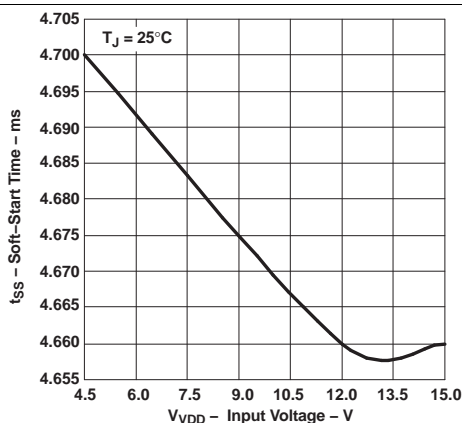


Figure 13. Soft Start Timing vs Input Voltage

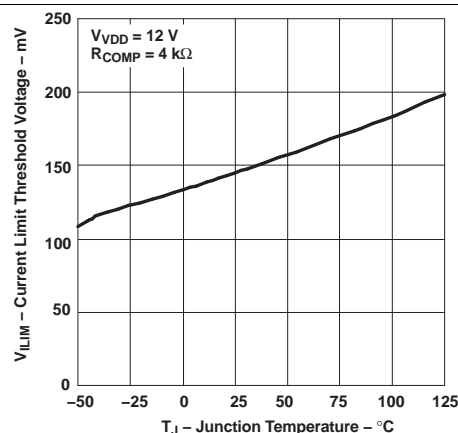


Figure 14. Current Limit Threshold vs Temperature

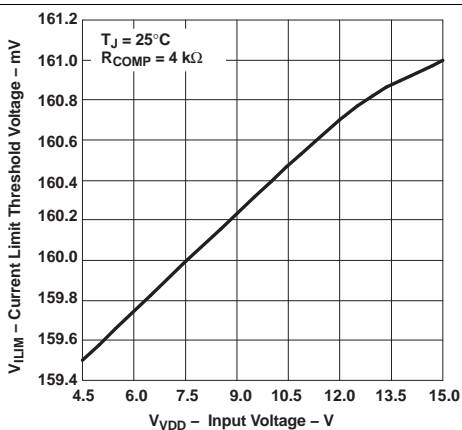


Figure 15. Current Limit Threshold vs Input Voltage

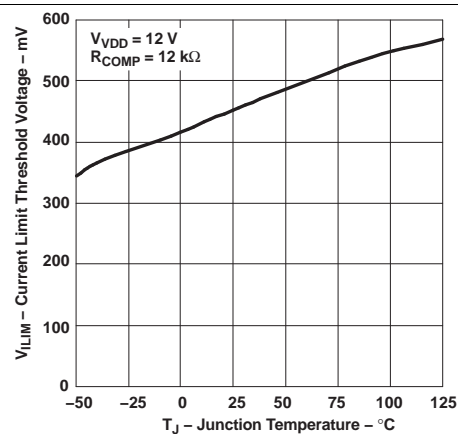


Figure 16. Current Limit Threshold vs Temperature

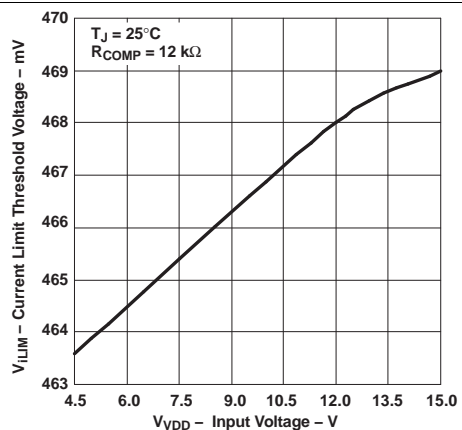


Figure 17. Current Limit Threshold vs Input Voltage

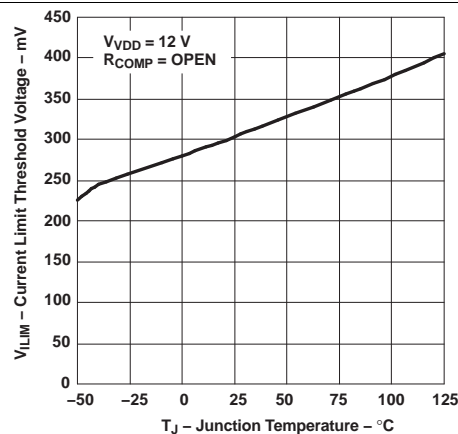
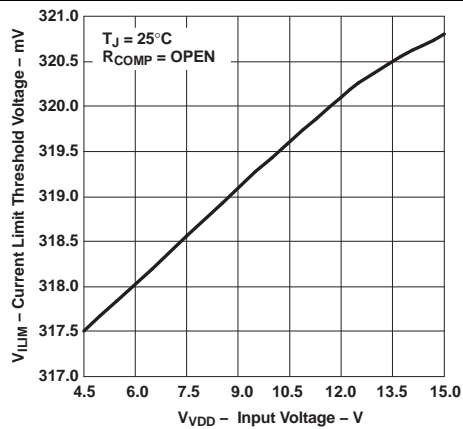
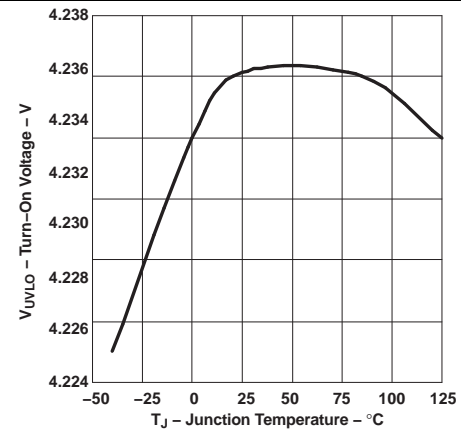


Figure 18. Current Limit Threshold vs Temperature

## Typical Characteristics (continued)



**Figure 19. Current Limit Threshold vs Input Voltage**



**Figure 20. Undervoltage Lockout Turn On Voltage vs Temperature**

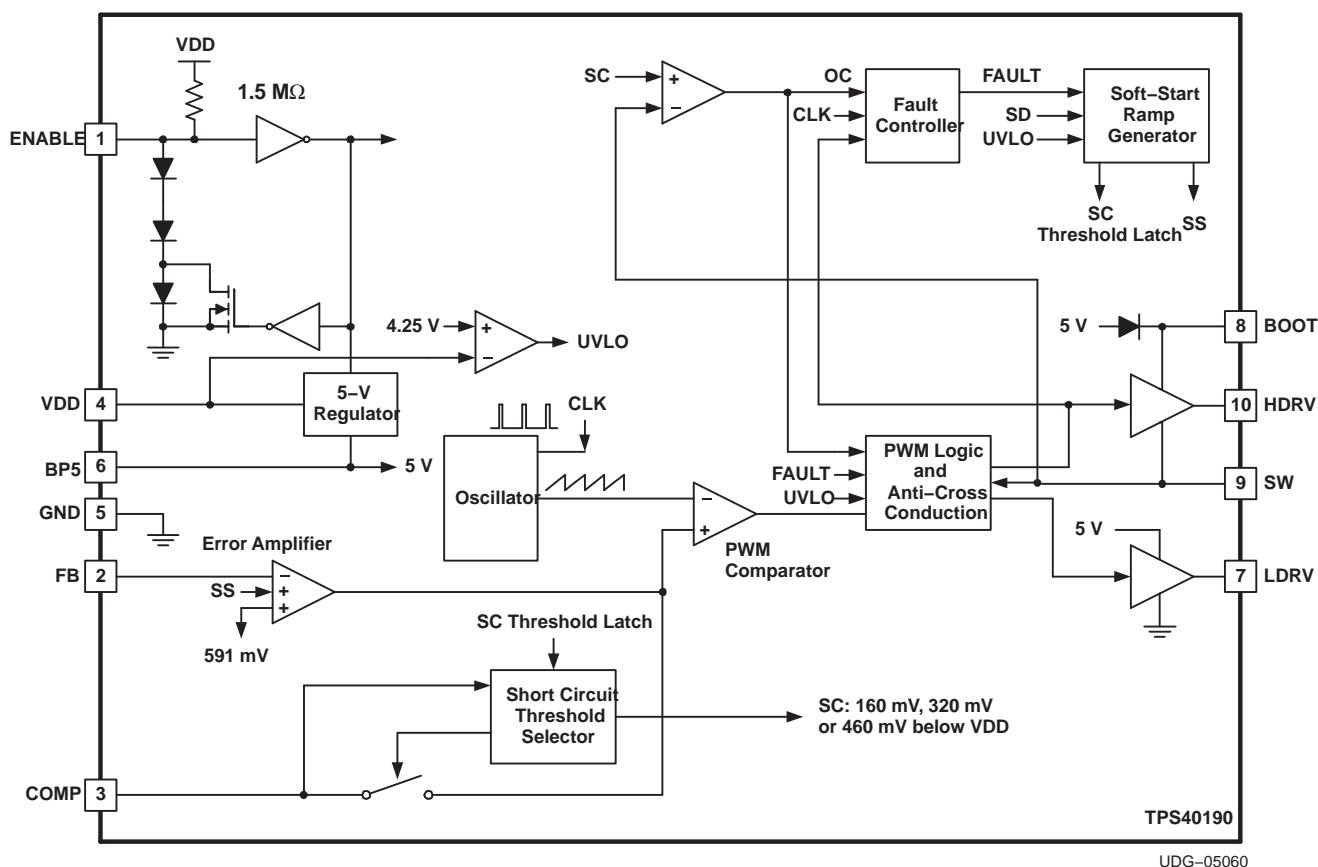
## 7 Detailed Description

### 7.1 Overview

The TPS40190 is a cost optimized controller providing all the necessary features to construct a high-performance DC-DC converter while keeping costs to a minimum. Support for pre-biased outputs eliminates concerns about damaging sensitive loads during start-up. Strong gate drivers for the high side and rectifier N-channel MOSFETs decrease switching losses for increased efficiency. Adaptive gate drive timing minimizes body diode conduction in the rectifier MOSFET, also increasing efficiency. Selectable short circuit protection thresholds and hiccup recovery from a short-circuit increase design flexibility and minimize power dissipation in the event of a prolonged output fault. A dedicated enable pin (ENABLE) allows the converter to be placed in a very low quiescent current shutdown mode.

Internally fixed switching frequency and soft-start time reduce external component count, simplifying design and layout, as well as reducing footprint and cost. The 3-mm × 3-mm package size also contributes to a reduced overall converter footprint.

### 7.2 Functional Block Diagram



### 7.3 Feature Description

#### 7.3.1 Internally Fixed Parameters

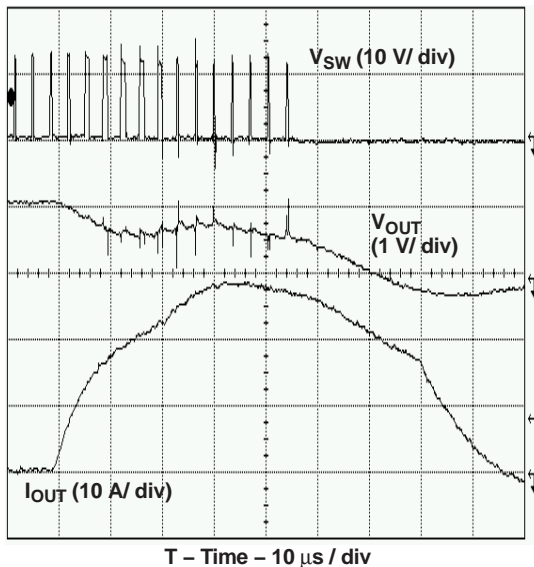
The TPS40190 has a fixed internal switching frequency of 300 kHz. Soft-start time is fixed at 4.7 ms typical and the UVLO level is set between 4.1 V and 4.4 V.

## Feature Description (continued)

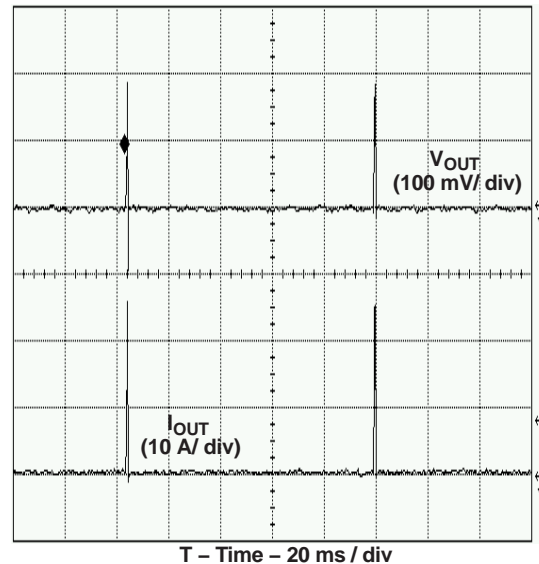
### 7.3.2 Output Short Circuit Protection

The short circuit detection in the TPS40190 is done by sensing the voltage drop across the high side FET when it is on. If the voltage drop across this FET exceeds the selected threshold in any given switching cycle, a counter counts up one count and the FET is turned off early. If the voltage drop across that FET does not exceed this threshold, the counter is decremented for that cycle and the FET is allowed to remain on for the normal pulse width commanded by the internal pulse width modulator. If the counter fills up (a count of 7) a fault condition is declared and the drivers turn both FETs off. After a timeout of approximately 95 ms, the controller attempts to restart. If a short circuit is still present at the output, the current ramps quickly up to the short-circuit threshold and another fault condition is declared. The device then waits 95 ms to attempt to restart again.

Typical waveforms during a short circuit event are shown in [Figure 21](#) and [Figure 22](#).



**Figure 21. Output Short Circuit Detected (Nominal Threshold 25 A)**

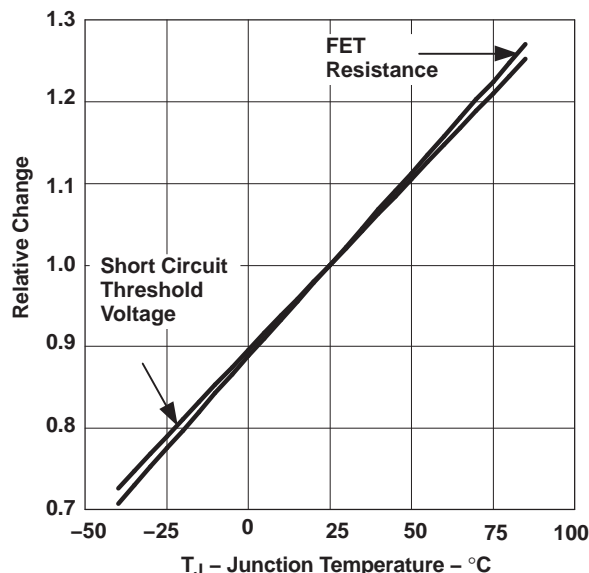


**Figure 22. Output Fault Hiccup Restart Timing**

The TPS40190 provides three selectable short circuit protection thresholds: 160 mV, 320 mV and 460 mV. The particular threshold is selected by connecting a resistor from COMP to GND. [Table 1](#) gives the short circuit thresholds for corresponding resistors from COMP to GND. Note that since the TPS40190 measures the resistance from COMP to GND during a 2-ms window, the compensation network from COMP to FB should have a time constant significantly less than 1 ms or there can be issues detecting the resistance and setting the correct short circuit threshold. This network should have no DC path from COMP to FB.

The short circuit detection threshold in the TPS40190 has some temperature compensation built in to help offset the high-side FET rise in resistance as its temperature rises. A typical FET has a resistance temperature coefficient of about 4500 ppm/°C. The temperature coefficient of the short circuit threshold is approximately 4200 ppm/°C. [Figure 23](#) shows how the short circuit threshold increases with temperature to help compensate for the FET resistance increase. The relative FET resistance change is based on an estimate of a linear 4500 ppm/°C temperature coefficient. The effectiveness of this compensation depends on how tight the thermal coupling between the TPS40190 and the high-side FET is. Better thermal coupling between the TPS40190 and the high-side FET gives better compensation effectiveness.

## Feature Description (continued)



**Figure 23. Relative Short Circuit Threshold Change vs Temperature**

**Table 1. Short Circuit Threshold Voltage Selection**

| SHORT CIRCUIT PROTECTION RESISTANCE, R <sub>COMP</sub> (kΩ) | NOMINAL CURRENT LIMIT VOLTAGE, V <sub>ILIM</sub> (mV) |
|---|---|
| 10.8 to 13.2  | 460   |
| OPEN  | 320   |
| 3.6 to 4.4  | 160   |

The range of short circuit current thresholds that can be expected is given by [Equation 1](#) and [Equation 2](#).

$$I_{SCP(max)} = \frac{V_{ILIM(max)}}{R_{DS(on)MIN}} \quad (1)$$

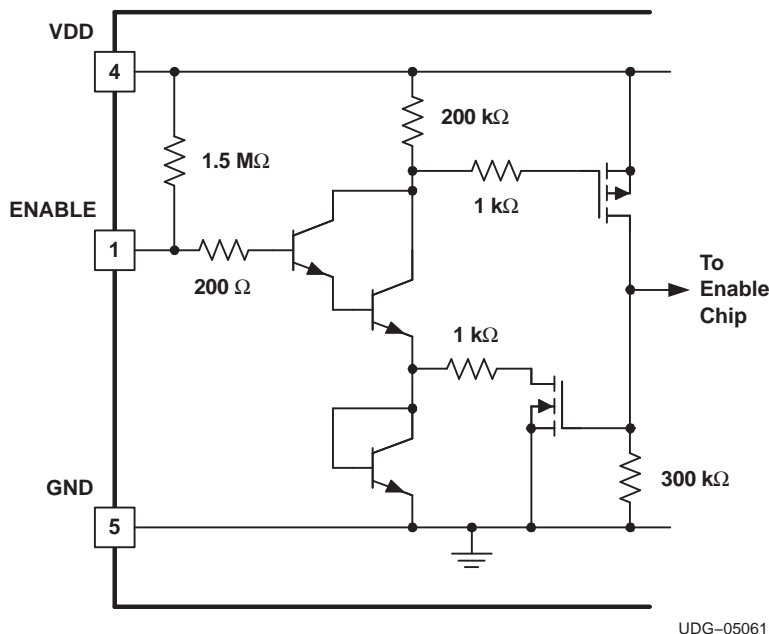
$$I_{SCP(min)} = \frac{V_{ILIM(min)}}{R_{DS(on)MAX}}$$

where

- $I_{SCP}$  is the short circuit current
  - $V_{ILIM}$  is the short circuit threshold
  - $R_{DS(on)}$  is the channel resistance of the high-side MOSFET
- (2)

### 7.3.3 Enable Functionality

The TPS40190 has a dedicated ENABLE pin. This simplifies user level interface design since no multiplexed functions exist. Another benefit is a true low power shutdown mode of operation. In this state, the BP5 regulator is turned off. When the ENABLE pin is pulled to GND, the TPS40190 consumes a typical 20-μA of current. A functionally equivalent circuit to the enable circuitry on the TPS40190 is shown in [Figure 24](#).



**Figure 24. TPS40190 ENABLE Pin Internal Circuitry**

If the ENABLE pin is left floating, the chip starts automatically. The pin must be pulled to less than 600 mV to ensure that the TPS40190 is in shutdown mode. Note that the ENABLE pin is relatively high impedance. In some situations, there could be enough noise nearby to cause the ENABLE pin to swing below the 600 mV threshold and give erroneous shutdown commands to the rest of the device. There are two solutions to this problem should it arise.

1. Place a capacitor from ENABLE to GND. A side effect of this is to delay the start of the converter while the capacitor charges past the enable threshold
2. Place a resistor from VDD to ENABLE. This causes more current to flow in the shutdown mode, but does not delay converter startup. If a resistor is used, the total current into the ENABLE pin should be limited to no more than 500  $\mu$ A.

The ENABLE pin is self-clamping. The clamp voltage can be as low as 1 V with a 1-k $\Omega$  ground impedance. Due to this self-clamping feature, the pull-up impedance on the ENABLE pin should be selected to limit the sink current to less than 500  $\mu$ A. Driving the ENABLE pin with a low-impedance source voltage can result in damage to the device. Because of the self-clamping feature, it requires care when connecting multiple ENABLE pins together. For enabling multiple TPS4019x devices (TPS40190, TPS40192, TPS40193, TPS40195, TPS40197), see the Application Report [SLVA509](#).

Typical waveforms for startup and shutdown using the ENABLE pin are shown in [Figure 25](#) and [Figure 26](#).

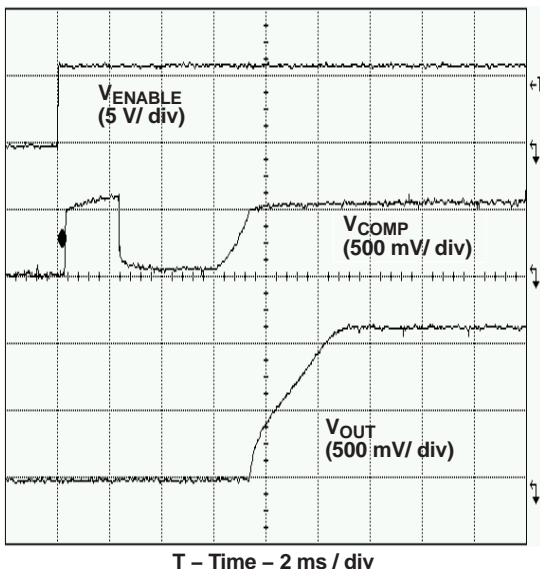


Figure 25. Startup Using ENABLE Pin

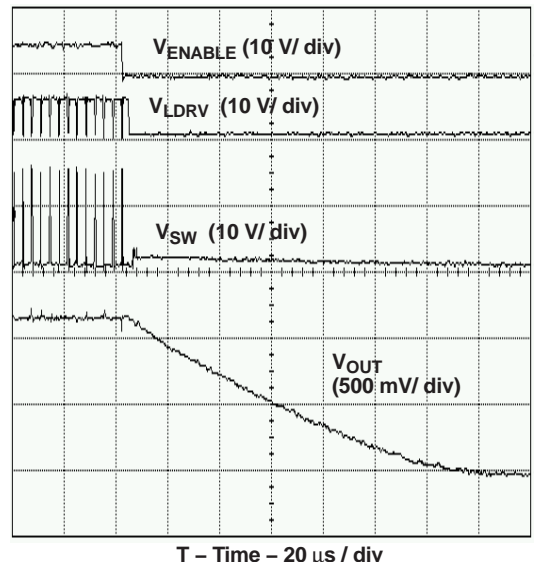


Figure 26. Shutdown Using ENABLE Pin

### 7.3.4 5-V Regulator

The TPS40190 has an on board 5-V regulator that allows the part to operate from a single voltage feed. No separate 5-V feed to the part is required. This regulator needs to have 4.7-μF of capacitance on the BP5 pin for stability. A ceramic capacitor is suggested for this purpose.

This regulator can also be used to supply power to nearby circuitry, eliminating the need for a separate LDO in some cases. If this pin is used for external loads, keep in mind that this is the power supply for the internals of the TPS40190. While efforts have been made to reduce sensitivity, any noise induced on this line has an adverse effect on the overall performance of the internal circuitry and shows up as increased pulse jitter, or skewed reference voltage. This regulator is turned off when the ENABLE pin is pulled low.

The amount of power available from this pin varies with the size of the power MOSFETs that the drivers must operate. Larger MOSFETs require more gate drive current and reduces the amount of power available on this pin for other tasks.

The total amount of current required by the gate drive and the external circuitry should not exceed 40 mA. The current required to drive the FET gates can be found from [Equation 3](#).

$$I_G = f_{SW} \times (Q_{G(high)} + Q_{G(low)})$$

Where

- $I_G$  is the required gate drive current
- $f_{SW}$  is the switching frequency (300 kHz)
- $Q_{G(high)}$  is the gate charge requirement for the high-side FET at 5 V  $V_{GS}$
- $Q_{G(low)}$  is the gate charge requirement for the low-side FET at 5 V  $V_{GS}$

(3)

### 7.3.5 Startup Sequence and Timing

The TPS40190 startup sequence is as follows. After input power is applied, the 5-V onboard regulator comes up. Once this regulator comes up, the TPS40190 goes through a period where it samples the impedance at the COMP pin and decides the short circuit protection threshold voltage. This is accomplished by placing 400 mV on the COMP pin for approximately 2 ms. During this time, the current is measured and compared against internal thresholds to select the short circuit protection threshold. After this, the COMP pin is brought low for 4 ms. This ensures that the feedback loop is preconditioned at startup and no sudden output rise occurs at the output of the converter when the converter is allowed to start switching. After these initial 6 milliseconds, the internal soft-start circuitry is engaged and the converter is allowed to start. See [Figure 27](#).

### 7.3.6 Prebias Outputs

Some applications require that the converter not sink current during start-up if a pre-existing voltage is higher than the output. Because synchronous buck converters inherently sink current some method of overcoming this characteristic must be employed. Applications that require this operation are typically power rails for a multi supply processor or ASIC. The method used in this controller, is to not allow the low side or rectifier FET to turn on until there the output voltage commanded by the start up ramp is higher than the pre-existing output voltage. This is detected by monitoring the internal pulse width modulator (PWM) for its first output pulse. Because this controller uses a closed loop startup, the first output pulse from the PWM does not occur until the output voltage is commanded to be higher than the pre-existing voltage. This effectively limits the controller to sourcing current only during the startup sequence.

If the pre-existing voltage is higher than the intended regulation point for the output of the converter, the converter starts and sinks current when the soft-start time has completed. A typical pre-biased start-up is shown in Figure 28.

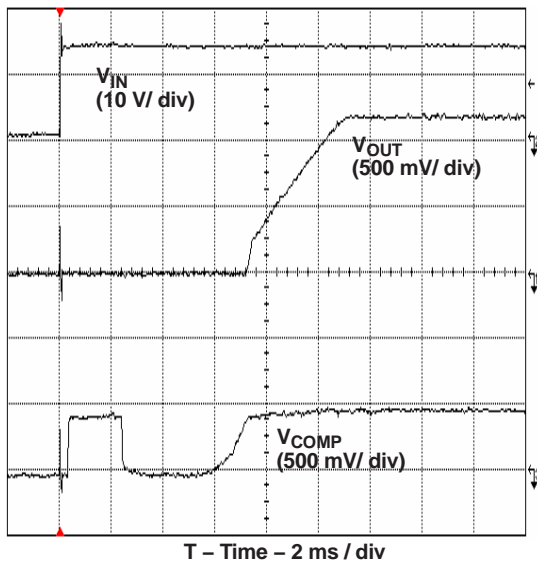


Figure 27. TPS40190 Start-up Timing

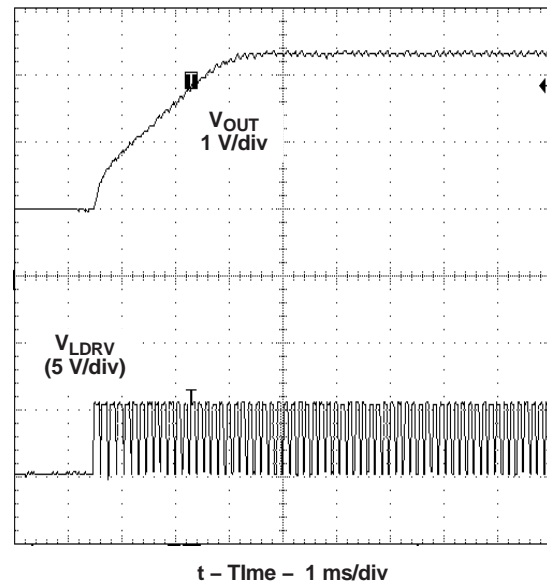


Figure 28. Prebiased Start-up Timing

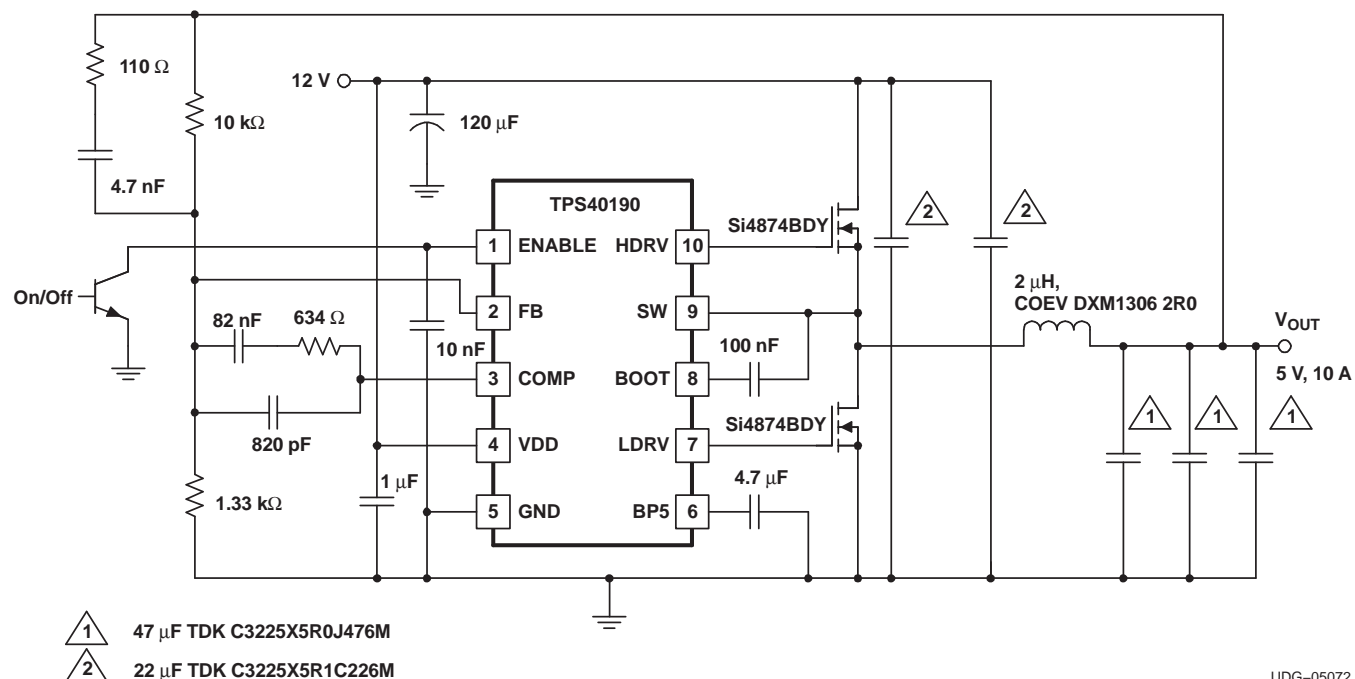


## 8 Application and Implementation

### NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 8.1 Typical Applications



UDG-05072

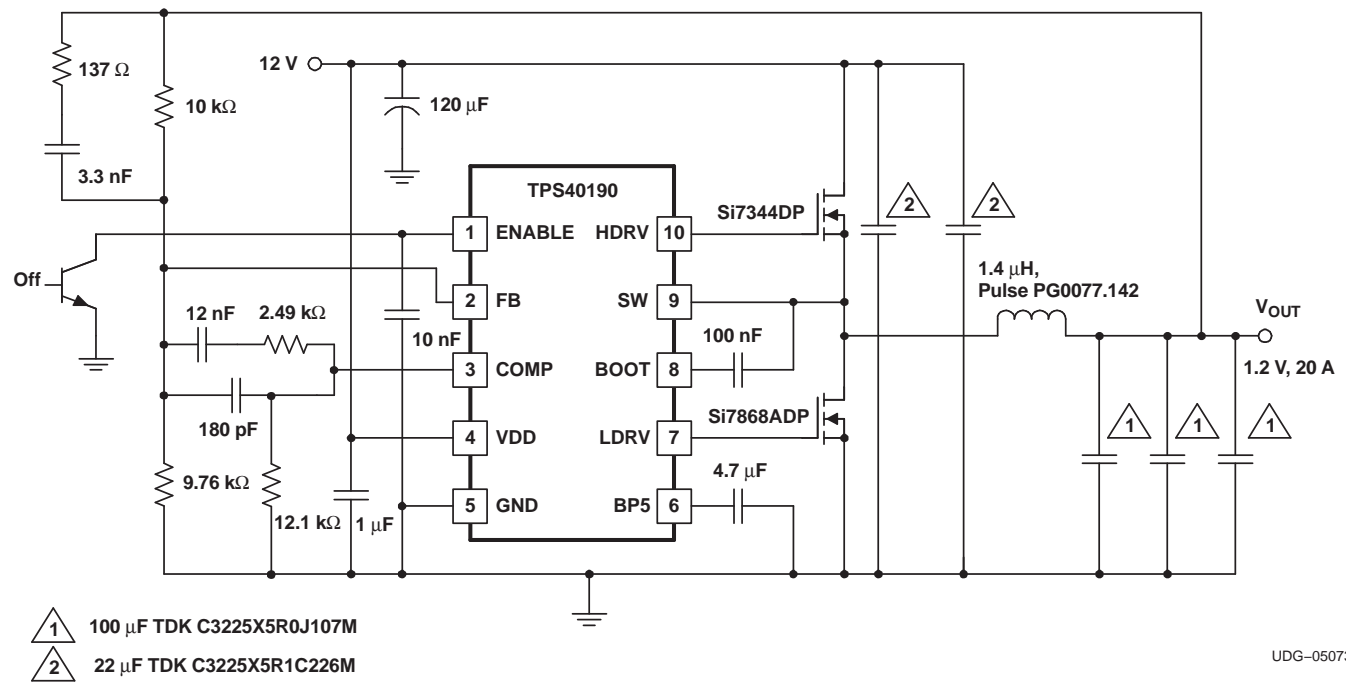
Figure 29. 12-V to 5-V at 10 A

## TPS40190

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### Typical Applications (continued)



**Figure 30. 12-V to 1.2-V at 20 A**

## Typical Applications (continued)

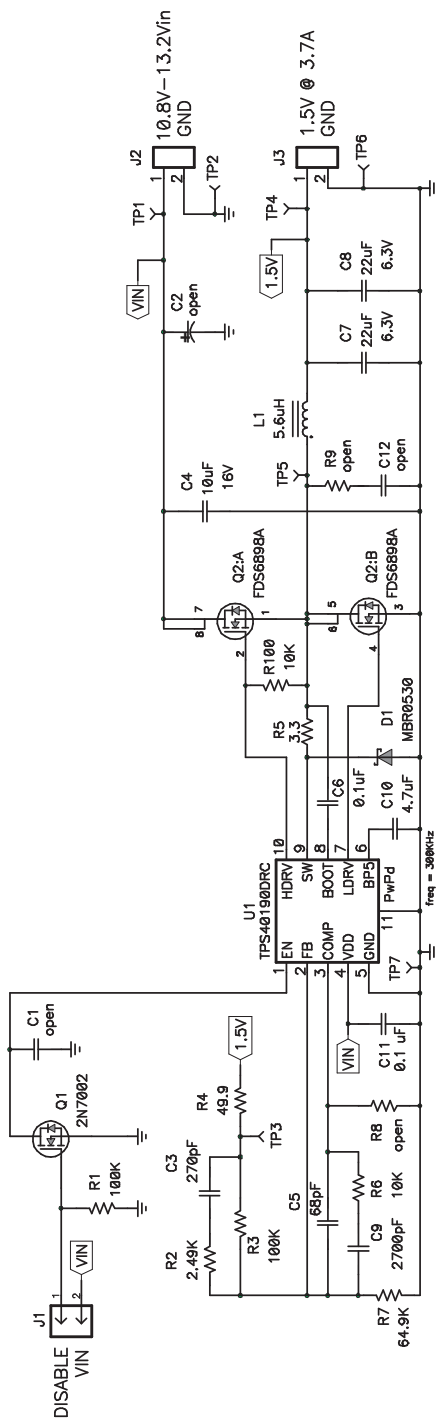


Figure 31. PMP1285, 12-V to 1.5-V, at 3.7 A

## 9 Device and Documentation Support

### 9.1 Documentation Support

#### 9.1.1 Related Documentation

For related documentation see the following:

- TI Application Report, *Enabling Multiple TPS4019x Devices*, [SLVA509](#)

### 9.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 9.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 9.4 Trademarks

E2E is a trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

### 9.5 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### 9.6 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## PACKAGING INFORMATION

| Orderable part number        | Status<br>(1) | Material type<br>(2) | Package   Pins  | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|------------------------------|---------------|----------------------|-----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">TPS40190DRCR</a> | Active        | Production           | VSON (DRC)   10 | 3000   LARGE T&R      | Yes         | NIPDAU   NIPDAUAG                    | Level-2-260C-1 YEAR               | -40 to 85    | 0190                |
| TPS40190DRCR.A               | Active        | Production           | VSON (DRC)   10 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 85    | 0190                |
| TPS40190DRCR.B               | Active        | Production           | VSON (DRC)   10 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 85    | 0190                |
| TPS40190DRCRG4               | Active        | Production           | VSON (DRC)   10 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 85    | 0190                |
| <a href="#">TPS40190DRCT</a> | Active        | Production           | VSON (DRC)   10 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | 0190                |
| TPS40190DRCT.A               | Active        | Production           | VSON (DRC)   10 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | 0190                |
| TPS40190DRCT.B               | Active        | Production           | VSON (DRC)   10 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | 0190                |
| TPS40190DRCTG4               | Active        | Production           | VSON (DRC)   10 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | 0190                |

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS40190DRCR | VSON         | DRC             | 10   | 3000 | 330.0              | 12.4               | 3.3     | 3.3     | 1.1     | 8.0     | 12.0   | Q2            |
| TPS40190DRCR | VSON         | DRC             | 10   | 3000 | 330.0              | 12.4               | 3.3     | 3.3     | 1.0     | 8.0     | 12.0   | Q2            |
| TPS40190DRCT | VSON         | DRC             | 10   | 250  | 180.0              | 12.4               | 3.3     | 3.3     | 1.1     | 8.0     | 12.0   | Q2            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS40190DRCR | VSON         | DRC             | 10   | 3000 | 346.0       | 346.0      | 33.0        |
| TPS40190DRCR | VSON         | DRC             | 10   | 3000 | 367.0       | 367.0      | 38.0        |
| TPS40190DRCT | VSON         | DRC             | 10   | 250  | 182.0       | 182.0      | 20.0        |



## GENERIC PACKAGE VIEW

**DRC 10**

**VSON - 1 mm max height**

3 x 3, 0.5 mm pitch

PLASTIC SMALL OUTLINE - NO LEAD

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



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## NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

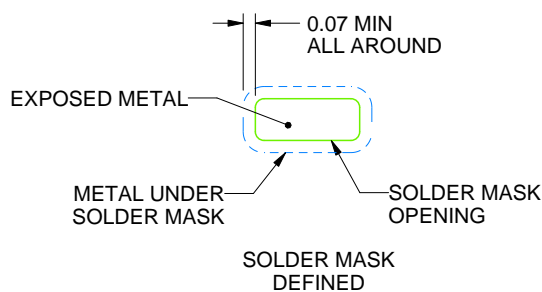
DRC0010J

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:20X



SOLDER MASK DETAILS

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NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).

5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

**DRC0010J**

**VSON - 1 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 11:  
80% PRINTED SOLDER COVERAGE BY AREA  
SCALE:25X

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NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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