1 Features
- Qualified for Automotive Applications
- 2.5-V to 6-V Input Voltage Range
- 18.5-V Boost Converter With 3.2-A Switch Current
- 650-kHz or 1.2-MHz Selectable Switching Frequency
- Adjustable Soft Start
- Thermal Shutdown
- Undervoltage Lockout
- 10-Pin VQFN Package with Wettable Flanks

2 Applications
- Automotive Infotainment Clusters
  - Instrument Clusters, Head Units
  - Radio, Navigation
  - Audio Amplifiers
- Automotive Body Electronics
  - Body Control Modules
  - Gateway
- Telemetrics and eCall
- Advanced Driver Assistance System (ADAS)

3 Description
The TPS61087-Q1 is a high-frequency, high-efficiency DC-to-DC converter with an integrated 3.2-A, 0.13-Ω power switch capable of providing an output voltage up to 18.5 V. The selectable frequency of 650 kHz or 1.2 MHz allows the use of small external inductors and capacitors, and provides fast transient response. The external compensation allows optimizing the application for specific conditions. A capacitor connected to the soft-start pin minimizes inrush current at start-up.

Device Information

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PACKAGE</th>
<th>BODY SIZE (NOM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPS61087-Q1</td>
<td>VSON (10)</td>
<td>3.00 mm x 3.00 mm</td>
</tr>
</tbody>
</table>

(1) For all available packages, see the orderable addendum at the end of the data sheet.
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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 A (June 2016) to Revision B Page
   • Changed ESD Ratings table to use AEC-Q100 specification .......................................................... 4
   • Added the Documentation Support and Receiving Notification of Documentation Updates sections ......................... 22

Changes from Original (December 2011) to Revision A Page
   • Added Applications section, Device Information table, Table of Contents, Revision History section, Specifications section, ESD Ratings table, Thermal Information table, Detailed Description section, Application and Implementation section, Power Supply Recommendations section, Layout section, Device and Documentation Support section, and Mechanical, Packaging, and Orderable Information section ........................................ 1
5 Pin Configuration and Functions

<table>
<thead>
<tr>
<th>PIN</th>
<th>I/O</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME</td>
<td>NO.</td>
<td>I/O</td>
</tr>
<tr>
<td>COMP</td>
<td>1</td>
<td>I/O</td>
</tr>
<tr>
<td>FB</td>
<td>2</td>
<td>I</td>
</tr>
<tr>
<td>EN</td>
<td>3</td>
<td>I</td>
</tr>
<tr>
<td>AGND</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>PGND</td>
<td>5</td>
<td>—</td>
</tr>
<tr>
<td>SW</td>
<td>6,7</td>
<td>I</td>
</tr>
<tr>
<td>IN</td>
<td>8</td>
<td>I</td>
</tr>
<tr>
<td>FREQ</td>
<td>9</td>
<td>I</td>
</tr>
<tr>
<td>SS</td>
<td>10</td>
<td>O</td>
</tr>
<tr>
<td>Thermal Pad</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

6 Specifications

6.1 Absolute Maximum Ratings

See (1)

<table>
<thead>
<tr>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>–0.3</td>
<td>7</td>
<td>V</td>
</tr>
<tr>
<td>–0.3</td>
<td>7</td>
<td>V</td>
</tr>
<tr>
<td>–0.3</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>–40</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>–65</td>
<td>150</td>
<td>°C</td>
</tr>
</tbody>
</table>

(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.

(2) All voltage values are with respect to network ground terminal.
6.2 ESD Ratings

<table>
<thead>
<tr>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>±2000</td>
<td>V</td>
</tr>
<tr>
<td>±1000</td>
<td>V</td>
</tr>
</tbody>
</table>

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_in</td>
<td>2.5</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td>V_s</td>
<td>V_in + 0.5</td>
<td>18.5</td>
<td>V</td>
</tr>
<tr>
<td>T_A</td>
<td>–40</td>
<td>125</td>
<td>°C</td>
</tr>
</tbody>
</table>

6.4 Thermal Information

<table>
<thead>
<tr>
<th>THERMAL METRIC(1)</th>
<th>THERMAL METRIC(1)</th>
<th>THERMAL METRIC(1)</th>
<th>THERMAL METRIC(1)</th>
<th>THERMAL METRIC(1)</th>
<th>THERMAL METRIC(1)</th>
<th>THERMAL METRIC(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_θJA</td>
<td>57</td>
<td>51.8</td>
<td>°C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_θJC(top)</td>
<td>84.5</td>
<td>81.3</td>
<td>°C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_θJB</td>
<td>31.5</td>
<td>26.2</td>
<td>°C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ψ_JT</td>
<td>5.9</td>
<td>4.4</td>
<td>°C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ψ_JB</td>
<td>31.6</td>
<td>26.4</td>
<td>°C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_θJC(bot)</td>
<td>13</td>
<td>7.6</td>
<td>°C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.

6.5 Electrical Characteristics

V_in = 5 V, EN = V_in, V_s = 15 V, T_A = T_J = –40°C to 125°C, typical values are at T_A = 25°C (unless otherwise noted)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_in</td>
<td>Input voltage range</td>
<td>2.5</td>
<td>6</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>I_Q</td>
<td>Operating quiescent current into IN pin</td>
<td>75</td>
<td>100</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>I_SDVIN</td>
<td>Shutdown current into IN pin</td>
<td>EN = GND</td>
<td>4</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>V_UVLO</td>
<td>Undervoltage lockout threshold</td>
<td>V_in falling</td>
<td>2.4</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>T_SD</td>
<td>Thermal shutdown</td>
<td>Temperature rising</td>
<td>150</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>T_SDHYS</td>
<td>Thermal shutdown hysteresis</td>
<td>14</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V_HH</td>
<td>High level input voltage</td>
<td>V_in = 2.5 V to 6 V</td>
<td>2</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>V_IL</td>
<td>Low level input voltage</td>
<td>V_in = 2.5 V to 6 V</td>
<td>0.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>I_INLEAK</td>
<td>Input leakage current</td>
<td>EN = FREQ = GND</td>
<td>0.1</td>
<td>μA</td>
<td></td>
</tr>
</tbody>
</table>
Electrical Characteristics (continued)

\[ V_{IN} = 5 \text{ V}, \; EN = V_{IN}, \; V_S = 15 \text{ V}, \; T_A = T_J = -40^\circ\text{C} \text{ to } 125^\circ\text{C}, \text{ typical values are at } T_A = 25^\circ\text{C} (\text{unless otherwise noted}) \]

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_S ) Boost output voltage</td>
<td>( V_{IN} = 0.5 )</td>
<td>18.5</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( V_{FB} ) Feedback regulation voltage</td>
<td>1.23</td>
<td>1.238</td>
<td>1.25</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( g_m ) Transconductance error amplifier</td>
<td>107</td>
<td></td>
<td></td>
<td>µA/V</td>
<td></td>
</tr>
<tr>
<td>( I_{FB} ) Feedback input bias current</td>
<td>( V_{FB} = 1.238 \text{ V} )</td>
<td>0.1</td>
<td>µA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( f_{DS(on)} ) N-channel MOSFET on-resistance</td>
<td>( V_{IN} = V_{GS} = 5 \text{ V}, ; I_{SW} = \text{current limit} )</td>
<td>0.13</td>
<td>0.18</td>
<td>Ω</td>
<td></td>
</tr>
<tr>
<td>( I_{SWLEAK} ) SW leakage current</td>
<td>( EN = \text{GND}, ; V_{SW} = V_{IN} = 6 \text{ V} )</td>
<td>0.16</td>
<td>0.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_{IM} ) N-Channel MOSFET current limit</td>
<td>( V_{SS} = 1.238 \text{ V} )</td>
<td>3.2</td>
<td>4</td>
<td>4.8</td>
<td>A</td>
</tr>
<tr>
<td>( I_{SS} ) Soft-start current</td>
<td>7</td>
<td>10</td>
<td>13</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>( f_s ) Oscillator frequency</td>
<td>( \text{FREQ} = V_{IN} )</td>
<td>0.9</td>
<td>1.2</td>
<td>1.5</td>
<td>MHz</td>
</tr>
<tr>
<td>( f_s ) Oscillator frequency</td>
<td>( \text{FREQ} = \text{GND} )</td>
<td>480</td>
<td>650</td>
<td>820</td>
<td>kHz</td>
</tr>
<tr>
<td>Line regulation</td>
<td>( V_{IN} = 2.5 \text{ V to 6 V}, ; I_{OUT} = 10 \text{ mA} )</td>
<td>0.0002</td>
<td></td>
<td>%/V</td>
<td></td>
</tr>
<tr>
<td>Load regulation</td>
<td>( V_{IN} = 5 \text{ V}, ; I_{OUT} = 1 \text{ mA to 1 A} )</td>
<td>0.11</td>
<td></td>
<td>%/A</td>
<td></td>
</tr>
</tbody>
</table>

6.6 Typical Characteristics

The typical characteristics are measured with the inductors 7447789003 3.3 µH (high frequency) or 74454068 6.8 µH (low frequency) from Wurth and the rectifier diode SL22.

Table 1. Table of Graphs

| \( I_{OUT(max)} \) Maximum load current | vs Input voltage at High frequency (1.2 MHz) | Figure 1 |
| \( I_{OUT(max)} \) Maximum load current | vs Input voltage at Low frequency (650 kHz) | Figure 2 |
| \( \eta \) Efficiency | vs Load current, \( V_S = 15 \text{ V}, \; V_{IN} = 5 \text{ V} \) | Figure 3 |
| Supply current | vs Supply voltage | Figure 5 |
| Oscillator frequency | vs Load current | Figure 6 |
| Oscillator frequency | vs Supply voltage | Figure 7 |
Typical Characteristics (continued)

![Figure 3. Efficiency vs Load Current](image1)

![Figure 4. Efficiency vs Load Current](image2)

![Figure 5. Supply Current vs Supply Voltage](image3)

![Figure 6. Oscillator Frequency vs Load Current](image4)

![Figure 7. Oscillator Frequency vs Supply Voltage](image5)
7 Detailed Description

7.1 Overview
The TPS61087-Q1 boost converter is designed for output voltages up to 18.5 V with a switch peak current limit of 3.2-A minimum. The device, which operates in a current mode scheme with quasi-constant frequency, is externally compensated for maximum flexibility and stability. The switching frequency is selectable from 650 kHz to 1.2 MHz and the minimum input voltage is 2.5 V. To limit the inrush current at start-up a soft-start pin is available.

TPS61087-Q1 boost converter’s novel topology using adaptive OFF-time provides superior load and line transient responses and operates also over a wider range of applications than conventional converters.

The selectable switching frequency offers the possibility to optimize the design either for the use of small sized components (1.2 MHz) or for higher system efficiency (650 kHz). However, the frequency changes slightly because the voltage drop across the \( r_{DS(on)} \) has some influence on the current and voltage measurement and thus on the ON-time (the OFF-time remains constant).

Depending on the load current, the converter operates in continuous conduction mode (CCM), discontinuous conduction mode (DCM), or pulse skip mode to maintain the output voltage.

7.2 Functional Block Diagram
7.3 Feature Description

7.3.1 Soft Start
The boost converter has an adjustable soft start to prevent high inrush current during start-up. To minimize the inrush current during start-up an external capacitor, connected to the SS pin and charged with a constant current, is used to slowly ramp up the internal current limit of the boost converter. When the EN pin is pulled high, the soft-start capacitor \(C_{SS}\) is immediately charged to 0.3 V. The capacitor is then charged at a constant current of 10 \(\mu\)A typically until the output of the boost converter \(V_S\) has reached its Power Good threshold (roughly 98% of \(V_S\) nominal value). During this time, the SS voltage directly controls the peak inductor current, starting with 0 A at \(V_{SS} = 0.3\) V up to the full current limit at \(V_{SS} = 800\) mV. The maximum load current is available after the soft start is completed. As the size of the capacitor increases the ramp of the current limit slows and the soft-start time increases. A 100-nF capacitor is usually sufficient for most of the applications. When the EN pin is pulled low, the soft-start capacitor is discharged to ground.

7.3.2 Frequency Select Pin (FREQ)
The switching frequency of the device is set using the frequency select pin (FREQ) to 650 kHz (FREQ = low) or 1.2 MHz (FREQ = high). Higher switching frequency improves load transient response but slightly reduces the efficiency. Another benefit of higher switching frequency is a lower output ripple voltage. Unless light load efficiency is a major concern, TI recommends using a 1.2-MHz switching frequency.

7.3.3 Undervoltage Lockout (UVLO)
To avoid misoperation of the device at low input voltages, an undervoltage lockout is included, which disables the device if the input voltage falls below 2.4 V.

7.3.4 Thermal Shutdown
A thermal shutdown is implemented to prevent damages due to excessive heat and power dissipation. Typically the thermal shutdown happens at a junction temperature of 150°C. When the thermal shutdown is triggered, the device stops switching until the junction temperature falls below typically 136°C. Then the device starts switching again.

7.3.5 Overvoltage Prevention
If overvoltage is detected on the FB pin (typically 3% above the nominal value of 1.238 V) the part stops switching immediately until the voltage on this pin drops to its nominal value. This prevents overvoltage on the output and secures the circuits connected to the output from excessive overvoltage.

7.4 Device Functional Modes
The converter operates in continuous conduction mode (CCM) as soon as the input current increases above half the ripple current in the inductor; for lower load currents, the converter switches into discontinuous conduction mode (DCM). If the load is further reduced, the part starts to skip pulses to maintain the output voltage.
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 Application Information
The TPS61087-Q1 is designed for output voltages up to 18.5 V with a switch peak current limit of 3.2-A minimum. The device, which operates in a current mode scheme with quasi-constant frequency, is externally compensated for maximum flexibility and stability. The switching frequency is selectable from 650 kHz to 1.2 MHz, and the input voltage range is from 2.3 V to 6 V. To control the inrush current at start-up a soft-start pin is available. The following section provides a step-by-step design approach for configuring the TPS61087-Q1 as a voltage regulating boost converter.

8.2 Typical Applications

8.2.1 Typical Application Circuit: 5 V to 15 V (f_S = 1.2 MHz)

![Application Diagram](image)

Figure 8. 5 V to 15 V (f_S = 1.2 MHz) Application Diagram

8.2.1.1 Design Requirements
For this design example, use the parameters shown in Table 2.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>EXAMPLE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage</td>
<td>5 V ± 20%</td>
</tr>
<tr>
<td>Output voltage</td>
<td>15 V</td>
</tr>
<tr>
<td>Output current</td>
<td>900 mA</td>
</tr>
<tr>
<td>Switching frequency</td>
<td>1.2 MHz</td>
</tr>
</tbody>
</table>

Table 2. Design Parameters
8.2.1.2 Detailed Design Procedure

The first step in the design procedure is to verify that the maximum possible output current of the boost converter supports the specific application requirements. A simple approach is to estimate the converter efficiency, by taking the efficiency numbers from the provided efficiency curves or to use a worst case assumption for the expected efficiency (for example: 90%).

Duty cycle (D) is calculated with Equation 1.

\[
D = 1 - \frac{V_{\text{IN}} \cdot \eta}{V_S}
\]  

(1)

Maximum output current \( (I_{\text{out(max)}}) \) is calculated with Equation 2.

\[
I_{\text{out(max)}} = \left( I_{\text{LIM(min)}} - \frac{\Delta I_L}{2} \right) \left( 1 - D \right)
\]  

(2)

Peak switch current in application \( (I_{\text{swpeak}}) \) is calculated with Equation 3.

\[
I_{\text{swpeak}} = \frac{\Delta I_L}{2} + \frac{I_{\text{out}}}{1 - D}
\]  

(3)

The inductor peak-to-peak ripple current \( (\Delta I_L) \) is calculated with Equation 4.

\[
\Delta I_L = \frac{V_{\text{IN}} \cdot D}{f_S \cdot L}
\]  

(4)

where
- \( V_{\text{IN}} \) is the minimum input voltage.
- \( V_S \) is the output voltage.
- \( I_{\text{LIM(min)}} \) is the converter switch current limit (minimum switch current limit = 3.2 A).
- \( f_S \) is the converter switching frequency (typically 1.2 MHz or 650 kHz).
- \( L \) is the selected inductor value.
- \( \eta \) is the estimated converter efficiency (use the number from the efficiency plots or 90% as an estimation).

The peak switch current is the steady state peak switch current that the integrated switch, inductor, and external Schottky diode must be able to handle. The calculation must be done for the minimum input voltage where the peak switch current is the highest.

8.2.1.2.1 Inductor Selection

The TPS61087-Q1 is designed to work with a wide range of inductors. The main parameter for the inductor selection is the saturation current of the inductor which must be higher than the peak switch current as calculated in Equation 3 with additional margin to cover for heavy load transients. A more conservative alternative is to choose an inductor with a saturation current at least as high as the maximum switch current limit of 4.8 A. The other important parameter is the inductor DC resistance. As the DC resistance decreases, the efficiency usually increases. It is important to note that the inductor DC resistance is not the only parameter determining the efficiency. Especially for a boost converter where the inductor is the energy storage element, the type and core material of the inductor influences the efficiency as well. At high switching frequencies of 1.2 MHz inductor core losses, proximity effects, and skin effects become more important. An inductor with a larger form factor usually gives higher efficiency. The efficiency difference between different inductors can vary from 2% to 10%. For the TPS61087-Q1, inductor values from 3 μH to 6 μH are a good choice with a switching frequency of 1.2 MHz, typically 3.3 μH. At 650 kHz, TI recommends inductors from 6 μH to 13 μH, typically 6.8 μH. See Table 3 for inductor selection. Customers must verify and validate selected components for suitability with their application.
TI recommends that the inductor current ripple is below 35% of the average inductor current. Equation 5 can be used to calculate the inductor value (L).

\[
L = \left( \frac{V_{oc}}{V_s} \right)^2 \cdot \left( \frac{V_s - V_{oc}}{I_{out} \cdot f_S} \right) \cdot \frac{\eta}{0.35}
\]

where
- \( I_{out} \) is the maximum output current in the application.

\[ (5) \]

Table 3. Inductor Selection

<table>
<thead>
<tr>
<th>INDUCTOR VALUE</th>
<th>TYPICAL DCR</th>
<th>( I_{sat} )</th>
<th>SUPPLIER</th>
<th>SIZE (L x W x H mm)</th>
<th>COMPONENT CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 MHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2 ( \mu )H</td>
<td>23 m( \Omega )</td>
<td>2.2 A</td>
<td>Sumida</td>
<td>5.7 \times 5.7 \times 3</td>
<td>CDRH5D28</td>
</tr>
<tr>
<td>4.7 ( \mu )H</td>
<td>60 m( \Omega )</td>
<td>2.5 A</td>
<td>Wurth Elektronik</td>
<td>5.9 \times 6.2 \times 3.3</td>
<td>7447785004</td>
</tr>
<tr>
<td>5 ( \mu )H</td>
<td>24 m( \Omega )</td>
<td>2.9 A</td>
<td>Coilcraft</td>
<td>7.3 \times 7.3 \times 4.1</td>
<td>MSS7341</td>
</tr>
<tr>
<td>5 ( \mu )H</td>
<td>23 m( \Omega )</td>
<td>2.4 A</td>
<td>Sumida</td>
<td>7 \times 7 \times 3</td>
<td>CDRH6D28</td>
</tr>
<tr>
<td>4.6 ( \mu )H</td>
<td>38 m( \Omega )</td>
<td>3.15 A</td>
<td>Sumida</td>
<td>7.6 \times 7.6 \times 3</td>
<td>CDR7D28</td>
</tr>
<tr>
<td>4.7 ( \mu )H</td>
<td>33 m( \Omega )</td>
<td>3.9 A</td>
<td>Wurth Elektronik</td>
<td>7.3 \times 7.3 \times 3.2</td>
<td>7447789004</td>
</tr>
<tr>
<td>3.3 ( \mu )H</td>
<td>30 m( \Omega )</td>
<td>4.2 A</td>
<td>Wurth Elektronik</td>
<td>7.3 \times 7.3 \times 3.2</td>
<td>7447789003</td>
</tr>
<tr>
<td>650 kHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 ( \mu )H</td>
<td>51 m( \Omega )</td>
<td>2.2 A</td>
<td>Wurth Elektronik</td>
<td>7.3 \times 7.3 \times 3.2</td>
<td>744778910</td>
</tr>
<tr>
<td>10 ( \mu )H</td>
<td>36 m( \Omega )</td>
<td>2.7 A</td>
<td>Sumida</td>
<td>8.3 \times 8.3 \times 3</td>
<td>CDRH8D28</td>
</tr>
<tr>
<td>6.8 ( \mu )H</td>
<td>52 m( \Omega )</td>
<td>2.9 A</td>
<td>Sumida</td>
<td>7 \times 7 \times 2.8</td>
<td>CDRH6D26HPNP</td>
</tr>
<tr>
<td>6.2 ( \mu )H</td>
<td>25 m( \Omega )</td>
<td>3.3 A</td>
<td>Sumida</td>
<td>8.3 \times 8.3 \times 6</td>
<td>CDRH8D58</td>
</tr>
<tr>
<td>10 ( \mu )H</td>
<td>80 m( \Omega )</td>
<td>3.5 A</td>
<td>Coilcraft</td>
<td>12.95 \times 9.4 \times 5.08</td>
<td>DS3316P</td>
</tr>
<tr>
<td>10 ( \mu )H</td>
<td>29 m( \Omega )</td>
<td>4 A</td>
<td>Sumida</td>
<td>8.3 \times 8.3 \times 4.5</td>
<td>CDRH8D43</td>
</tr>
<tr>
<td>6.8 ( \mu )H</td>
<td>55 m( \Omega )</td>
<td>4.1 A</td>
<td>Wurth Elektronik</td>
<td>12.7 \times 10 \times 4.9</td>
<td>74454068</td>
</tr>
</tbody>
</table>

8.2.1.2.2 Rectifier Diode Selection

To achieve high efficiency a Schottky type must be used for the rectifier diode. The reverse voltage rating must be higher than the maximum output voltage of the converter. The averaged rectified forward current (\( I_{avg} \)), the Schottky diode must be rated for, is equal to the output current (\( I_{out} \)).

\[
I_{avg} = I_{out}
\]

\[ (6) \]

Usually a Schottky diode with 2-A maximum average rectified forward current rating is sufficient for most applications. The Schottky rectifier can be selected with lower forward current capability depending on the output current but must be able to dissipate the power. The dissipated power (\( P_D \)) is the average rectified forward current times the diode forward voltage (\( V_{forward} \)).

\[
P_D = I_{avg} \cdot V_{forward}
\]

\[ (7) \]

Typically the diode must be able to dissipate around 500 mW depending on the load current and forward voltage. See Table 4 for diode selection. Customers must verify and validate selected components for suitability with their application.

Table 4. Rectifier Diode Selection

<table>
<thead>
<tr>
<th>( I_{avg} )</th>
<th>( V_R )</th>
<th>( V_{forward} )</th>
<th>SUPPLIER</th>
<th>COMPONENT CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 A</td>
<td>20 V</td>
<td>0.44 V</td>
<td>Vishay Semiconductor</td>
<td>SL22</td>
</tr>
<tr>
<td>2 A</td>
<td>20 V</td>
<td>0.5 V</td>
<td>Fairchild Semiconductor</td>
<td>SS22</td>
</tr>
</tbody>
</table>
8.2.1.2.3 Setting the Output Voltage

The output voltage is set by an external resistor divider. Typically, a minimum current of 50 μA flowing through the feedback divider gives good accuracy and noise covering. A standard low side resistor of 18 kΩ is typically selected. The resistors are then calculated as shown in Equation 8:

\[
R_2 = \frac{V_{FB}}{70\mu A} \approx 18k\Omega \\
R_1 = R_2 \cdot \left( \frac{V_s}{V_{FB}} - 1 \right) \\
V_{FB} = 1.238V
\]

8.2.1.2.4 Compensation (COMP)

The regulator loop can be compensated by adjusting the external components connected to the COMP pin. The COMP pin is the output of the internal transconductance error amplifier.

Equation 9 can be used to calculate \( R_{\text{COMP}} \) and \( C_{\text{COMP}} \).

\[
R_{\text{COMP}} = \frac{110 \cdot V_{IN} \cdot V_s \cdot C_{\text{out}}}{L \cdot I_{out}} \\
C_{\text{COMP}} = \frac{V_s \cdot C_{\text{out}}}{7.5 \cdot I_{out} \cdot R_{\text{COMP}}}
\]

where

- \( C_{\text{out}} \) is the output capacitance.

Make sure that \( R_{\text{COMP}} < 120 \, k\Omega \) and \( C_{\text{COMP}} > 820 \, pF \), independent of the results of the above formulas.

See Table 5 for dedicated compensation networks giving an improved load transient response. These conservative \( R_{\text{COMP}} \) and \( C_{\text{COMP}} \) values for certain inductors, input, and output voltages provide a very stable system. For a faster response time, a higher \( R_{\text{COMP}} \) value can be used to enlarge the bandwidth, as well as a slightly lower value of \( C_{\text{COMP}} \) to keep enough phase margin. These adjustments must be performed in parallel with the load transient response monitoring of TPS61087-Q1.

Standard values of \( R_{\text{COMP}} = 16 \, k\Omega \) and \( C_{\text{COMP}} = 2.7 \, nF \) works for the majority of the applications.

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>L</th>
<th>( V_s )</th>
<th>( V_{IN} \pm 20% )</th>
<th>( R_{\text{COMP}} )</th>
<th>( C_{\text{COMP}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (1.2 MHz)</td>
<td>3.3 μH</td>
<td>15 V</td>
<td>5 V</td>
<td>100 kΩ</td>
<td>820 pF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.3 V</td>
<td>91 kΩ</td>
<td>1.2 nF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 V</td>
<td>5 V</td>
<td>68 kΩ</td>
<td>820 pF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.3 V</td>
<td>68 kΩ</td>
<td>1.2 nF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 V</td>
<td>5 V</td>
<td>39 kΩ</td>
<td>820 pF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.3 V</td>
<td>39 kΩ</td>
<td>1.2 nF</td>
</tr>
<tr>
<td>Low (650 kHz)</td>
<td>6.8 μH</td>
<td>15 V</td>
<td>5 V</td>
<td>51 kΩ</td>
<td>1.5 nF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.3 V</td>
<td>47 kΩ</td>
<td>2.7 nF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 V</td>
<td>5 V</td>
<td>33 kΩ</td>
<td>1.5 nF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.3 V</td>
<td>33 kΩ</td>
<td>2.7 nF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 V</td>
<td>5 V</td>
<td>18 kΩ</td>
<td>1.5 nF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.3 V</td>
<td>18 kΩ</td>
<td>2.7 nF</td>
</tr>
</tbody>
</table>

8.2.1.2.5 Input Capacitor Selection

TI recommends low ESR ceramic capacitors for good input voltage filtering. TPS61087-Q1 has an analog input (IN). Therefore, TI recommends placing a 1-μF bypass capacitor as close as possible to the IC from IN to GND.

Two 10-μF (or one 22-μF) ceramic input capacitors are sufficient for most of the applications. For better input voltage filtering this value can be increased. See Table 6 for output capacitor selection. Customers must verify and validate selected components for suitability with their application.
8.2.1.2.6 Output Capacitor Selection

TI recommends low ESR ceramic capacitors for best output voltage filtering. Four 10-µF (or two 22-µF) ceramic output capacitors work for most of the applications. Higher capacitor values can be used to improve the load transient response. See Table 6 for output capacitor selection. DC voltage derating factor must also be considered while choosing capacitors. Customers must verify and validate selected components for suitability with their application.

Table 6. Rectifier Input and Output Capacitor Selection

<table>
<thead>
<tr>
<th>CAPACITOR (SIZE)</th>
<th>VOLTAGE RATING</th>
<th>SUPPLIER</th>
<th>COMPONENT CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>C_IN</td>
<td>22 µF (1206)</td>
<td>16 V</td>
<td>Taiyo Yuden</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EMK316 BJ 226ML</td>
</tr>
<tr>
<td>IN bypass</td>
<td>1 µF (0603)</td>
<td>16 V</td>
<td>Taiyo Yuden</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EMK107 BJ 105KA</td>
</tr>
<tr>
<td>C_OUT</td>
<td>10 µF (1206)</td>
<td>25 V</td>
<td>Taiyo Yuden</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TMK316 BJ 106KL</td>
</tr>
</tbody>
</table>

To calculate the output voltage ripple, use Equation 10.

\[ \Delta V_C = \frac{V_S - V_{IN}}{V_S \cdot f_S} \cdot \frac{I_{out}}{C_{out}} \]

\[ \Delta V_{C_{ESR}} = I_{L(peak)} \cdot R_{C_{ESR}} \]

where

- \( \Delta V_C \) is the output voltage ripple dependent on output capacitance, output current, and switching frequency.
- \( \Delta V_{C_{ESR}} \) is the output voltage ripple due to output capacitors ESR (equivalent series resistance).
- \( I_{L(peak)} \) is the inductor peak switch current in the application.
- \( R_{C_{ESR}} \) is the output capacitors equivalent series resistance (ESR).

\( \Delta V_{C_{ESR}} \) can be neglected in many cases because ceramic capacitors provide low ESR.

8.2.1.3 Application Curves

![Figure 9. PWM Switching Discontinuous Conduction Mode](image1)

![Figure 10. PWM Switching Continuous Conduction Mode](image2)
Figure 11. Load Transient Response High Frequency (1.2 MHz)

Figure 12. Load Transient Response Low Frequency (650 kHz)

Figure 13. Soft Start
8.2.2 Other Application Circuit Examples

Figure 14 to Figure 22 show application circuit examples using the TPS61087-Q1 device. These circuits must be fully validated and tested by customers before using these circuits in their designs. TI does not warrant the accuracy or completeness of these circuits, nor does TI accept any responsibility for them.

Figure 14. 5-V to 15-V Application Diagram

Figure 15. 3.3-V to 9-V Application Diagram
**Figure 16. 3.3-V to 9-V Application Diagram**

- $f_S = 650 \text{ kHz}$
- $V_S = 9 \text{ V}$
- $I_{OUT(max)} = 950 \text{ mA}$

- $C_{in} = 2 \times 10 \mu F/16 \text{ V}$
- $C_{by} = 1 \mu F/16 \text{ V}$
- $L = 6.8 \mu H$
- $R_{iso} = 10 \text{ k}\Omega$
- $R_{comp} = 51 \text{ k}\Omega$
- $C_{comp} = 1.5 \text{ nF}$
- $C_{ss} = 100 \text{ nF}$
- $R_1 = 110 \text{ k}\Omega$
- $R_2 = 18 \text{ k}\Omega$
- $C_{out} = 4 \times 10 \mu F$/$25 \text{ V}$
- $V_{IN} = 3.3 \text{ V} \pm 20\%$
- $V_{S} = 9 \text{ V}$
- $V_{out} = 950 \text{ mA}$

**Figure 17. Diagram for Application With External Load Disconnect Switch**

- $f_S = 650 \text{ kHz}$
- $V_S = 15 \text{ V}$
- $I_{OUT} = 300 \text{ mA}$

- $C_{in} = 2 \times 10 \mu F/16 \text{ V}$
- $C_{by} = 1 \mu F$/$16 \text{ V}$
- $L = 6.8 \mu H$
- $C_{ss} = 100 \text{ nF}$
- $R_{comp} = 51 \text{ k}\Omega$
- $C_{comp} = 1.5 \text{ nF}$
- $R_1 = 200 \text{ k}\Omega$
- $R_2 = 18 \text{ k}\Omega$
- $C_{out} = 4 \times 10 \mu F$/$25 \text{ V}$
- $V_{IN} = 5 \text{ V} \pm 20\%$
- $V_{S} = 15 \text{ V}$
Figure 18. Application Diagram for 5 V to 15 V With Overvoltage Protection

\[ f_S = 650 \text{ kHz} \quad V_S = 15 \text{ V} \quad I_{OUT(max)} = 900 \text{ mA} \]
Figure 19. Application Diagram for 5 V to 15 V for TFT LCD With External Charge Pumps (VGH, VGL)

\[ f_S = 1.2 \text{ MHz} \quad V_S = 15 \text{ V} \quad I_{OUT} = 500 \text{ mA} \]
Figure 20. Application Diagram for wLED Supply (3S3P) With Optional Clamping Zener Diode

\[ f_S = 650 \text{ kHz} \quad I_{\text{OUT}} = 500 \text{ mA} \]

Figure 21. Application Diagram for wLED Supply (3S3P) With Adjustable Brightness Control Using A PWM Signal On The Enable Pin With Optional Clamping Zener Diode

\[ f_S = 650 \text{ kHz} \quad I_{\text{OUT}} = 500 \text{ mA} \]
9 Power Supply Recommendations

The TPS61087-Q1 is designed to operate from an input voltage supply range from 2.3 V to 6 V. The power supply to the TPS61087-Q1 must have a current rating according to the supply voltage, output voltage, and output current of the TPS61087-Q1.

10 Layout

10.1 Layout Guidelines

For all switching power supplies, the layout is an important step in the design, especially at high peak currents and high switching frequencies. If the layout is not carefully done, the regulator could show stability problems as well as EMI problems.

Figure 23 provides an example of layout design with the TPS61087-Q1 device.

- Use wide and short traces for the main current path and for the power ground tracks.
- The input capacitor, output capacitor, and the inductor must be placed as close as possible to the IC.
- Use a common ground node for power ground and a different one for control ground to minimize the effects of ground noise. Connect these ground nodes at the GND terminal of the IC.
- The most critical current path for all boost converters is from the switching FET, through the rectifier diode, then the output capacitors, and back to ground of the switching FET. Therefore, the output capacitors and their traces must be placed on the same board layer as the IC and as close as possible between the SW pin and the GND terminal of the IC.
10.2 Layout Example

Figure 23. TPS61087-Q1 Layout Example
11 Device and Documentation Support

11.1 Device Support

11.1.1 Third-Party Products Disclaimer

TI's publication of information regarding third-party products or services does not constitute an endorsement regarding the suitability of such products or services or a warranty, representation or endorsement of such products or services, either alone or in combination with any TI product or service.

11.2 Documentation Support

11.2.1 Related Documentation

For related documentation see the following:

- Performing Accurate PFM Mode Efficiency Measurements
- QFN/SON PCB Attachment

11.3 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.

11.4 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.

11.5 Trademarks

E2E is a trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

11.6 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.

11.7 Glossary

**SLYZ022 — TI Glossary.**

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

12 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

<table>
<thead>
<tr>
<th>Orderable Device</th>
<th>Status</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>Package Qty</th>
<th>Eco Plan (1)</th>
<th>Lead/Ball Finish (6)</th>
<th>MSL Peak Temp (3)</th>
<th>Op Temp (°C)</th>
<th>Device Marking (4/5)</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPS61087QDRCRQ1</td>
<td>ACTIVE</td>
<td>VSON</td>
<td>DRC</td>
<td>10</td>
<td>3000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-3-260C-168 HR</td>
<td>-40 to 125</td>
<td>PMOQ</td>
<td></td>
</tr>
<tr>
<td>TPS61087QWDRCRQ1</td>
<td>ACTIVE</td>
<td>VSON</td>
<td>DRC</td>
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<td>CU SN</td>
<td>Level-3-260C-168 HR</td>
<td>-40 to 125</td>
<td>11ZC</td>
<td></td>
</tr>
</tbody>
</table>

(1) The marketing status values are defined as follows:
- **ACTIVE**: Product device recommended for new designs.
- **LIFEBUY**: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
- **NRND**: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
- **PREVIEW**: Device has been announced but is not in production. Samples may or may not be available.
- **OBSOLETE**: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check [http://www.ti.com/productcontent](http://www.ti.com/productcontent) for the latest availability information and additional product content details.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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Addendum-Page 1
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**OTHER QUALIFIED VERSIONS OF TPS61087-Q1:**

- Catalog: TPS61087

**NOTE: Qualified Version Definitions:**

- Catalog - TI's standard catalog product
### TAPE AND REEL INFORMATION

#### TAPE DIMENSIONS

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0</td>
<td>Dimension designed to accommodate the component width</td>
</tr>
<tr>
<td>B0</td>
<td>Dimension designed to accommodate the component length</td>
</tr>
<tr>
<td>K0</td>
<td>Dimension designed to accommodate the component thickness</td>
</tr>
<tr>
<td>W</td>
<td>Overall width of the carrier tape</td>
</tr>
<tr>
<td>P1</td>
<td>Pitch between successive cavity centers</td>
</tr>
</tbody>
</table>

#### REEL DIMENSIONS

- **Reel Diameter:** 330.0 mm
- **Reel Width (W1):** 12.4 mm

#### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE

- **User Direction of Feed:** Q1, Q2, Q3, Q4

#### Device Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>SPQ</th>
<th>Reel Diameter (mm)</th>
<th>Reel Width W1 (mm)</th>
<th>A0 (mm)</th>
<th>B0 (mm)</th>
<th>K0 (mm)</th>
<th>P1 (mm)</th>
<th>W (mm)</th>
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<td>3.3</td>
<td>1.1</td>
<td>8.0</td>
<td>12.0</td>
<td>Q2</td>
</tr>
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</table>

*All dimensions are nominal.*

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**Pack Materials-Page 1**
**TAPE AND REEL BOX DIMENSIONS**

*All dimensions are nominal*

<table>
<thead>
<tr>
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<th>Package Drawing</th>
<th>Pins</th>
<th>SPQ</th>
<th>Length (mm)</th>
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<td>3000</td>
<td>367.0</td>
<td>367.0</td>
<td>35.0</td>
</tr>
</tbody>
</table>
Images above are just a representation of the package family, actual package may vary. Refer to the product data sheet for package details.
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.
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/slua271).

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.
NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
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.
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/slua271).

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