TPS82130 17-V Input 3-A Step-Down Converter MicroSiP™ Module with Integrated Inductor

1 Features
- 3-mm × 2.8-mm × 1.5-mm MicroSiP™ package
- 3-V to 17-V input range
- 3-A continuous output current
- DCS-Control™ topology
- Power save mode for light-load efficiency
- 20-µA operating quiescent current
- 0.9-V to 6-V adjustable output voltage
- 100% duty cycle for lowest dropout
- Power-good output
- Programmable soft start-up with tracking
- Thermal shutdown protection
- –40°C to 125°C operating temperature range
- Create a custom design using the TPS82130 with the WEBENCH® Power Designer

2 Applications
- Industrial applications
- Telecom and networking applications
- Solid state drives

3 Description
The TPS82130 is a 17-V input 3-A step-down converter MicroSiP power module optimized for small solution size and high efficiency. The module integrates a synchronous step-down converter and an inductor to simplify design, reduce external components, and save PCB area. The low profile and compact solution is suitable for automated assembly by standard surface mount equipment.

To maximize efficiency, the converter operates in PWM mode with a nominal switching frequency of 2 MHz and automatically enters power save mode operation at light load currents. In power save mode, the device operates with 20-µA (typical) quiescent current. Using the DCS-Control topology, the device achieves excellent load transient performance and accurate output voltage regulation.

Device Information

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PACKAGE(1)</th>
<th>BODY SIZE (NOM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPS82130</td>
<td>µSiL (8)</td>
<td>3.00 mm × 2.80 mm</td>
</tr>
</tbody>
</table>

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

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.
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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 D (November 2018) to Revision E (October 2021)  Page
• Updated the numbering format for tables, figures, and cross-references throughout the document .............................. 1
• Corrected grammar throughout document ........................................... 1

Changes from Revision C (January 2017) to Revision D (November 2018)  Page
• Added Tape and Reel Information ................................................... 24

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5 Pin Configuration and Functions

![Diagram of 8-Pin µSiL Package (SIL0008C Top View)](image)

Table 5-1. Pin Functions

<table>
<thead>
<tr>
<th>PIN NAME</th>
<th>NO.</th>
<th>I/O</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN</td>
<td>1</td>
<td>I</td>
<td>Enable pin. Pull High to enable the device. Pull Low to disable the device. This pin has an internal pulldown resistor of typically 400 kΩ when the device is disabled.</td>
</tr>
<tr>
<td>VIN</td>
<td>2</td>
<td>PWR</td>
<td>Input pin</td>
</tr>
<tr>
<td>GND</td>
<td>3</td>
<td></td>
<td>Ground pin</td>
</tr>
<tr>
<td>VOUT</td>
<td>4, 5</td>
<td>PWR</td>
<td>Output pin</td>
</tr>
<tr>
<td>FB</td>
<td>6</td>
<td>I</td>
<td>Feedback reference pin. An external resistor divider connected to this pin programs the output voltage.</td>
</tr>
<tr>
<td>PG</td>
<td>7</td>
<td>O</td>
<td>Power-good open-drain output pin. A pullup resistor can be connected to any voltage less than 6 V. Leave it open if it is not used.</td>
</tr>
<tr>
<td>SS/TR</td>
<td>8</td>
<td>I</td>
<td>Soft start-up and voltage tracking pin. An external capacitor connected to this pin sets the internal reference voltage rising time.</td>
</tr>
<tr>
<td>Exposed Thermal Pad</td>
<td></td>
<td></td>
<td>The exposed thermal pad must be connected to the GND pin. Must be soldered to achieve appropriate power dissipation and mechanical reliability.</td>
</tr>
</tbody>
</table>

Figure 5-1. 8-Pin µSiL Package (SIL0008C Top View)
6 Specifications

6.1 Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Voltage at pins</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) VIN</td>
<td>–0.3</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>(2) EN, SS/TR</td>
<td>–0.3</td>
<td>V&lt;sub&gt;IN&lt;/sub&gt; + 0.3</td>
<td>V</td>
</tr>
<tr>
<td>PG, FB</td>
<td>–0.3</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>VOUT</td>
<td>0</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Sink current</td>
<td></td>
<td>10</td>
<td>mA</td>
</tr>
<tr>
<td>Module operating temperature</td>
<td>–40</td>
<td>125</td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>–55</td>
<td>125</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, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) All voltage values are with respect to network ground pin.

6.2 ESD Ratings

<table>
<thead>
<tr>
<th>Electrostatic discharge</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human body model (HBM), per ANSI/ESDA/JEDEC JS-001</td>
<td>±2000</td>
<td>V</td>
</tr>
<tr>
<td>Charged device model (CDM), per JEDEC specification JESD22-C101</td>
<td>±1000</td>
<td>V</td>
</tr>
</tbody>
</table>

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommend Operating Conditions

<table>
<thead>
<tr>
<th>Over operating free-air temperature range, unless otherwise noted.</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;sub&gt;IN&lt;/sub&gt; Input voltage</td>
<td>3</td>
<td>17</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;PG&lt;/sub&gt; Power good pull-up resistor voltage</td>
<td>6</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;OUT&lt;/sub&gt; Output voltage</td>
<td>0.9</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td>I&lt;sub&gt;OUT&lt;/sub&gt; Output current</td>
<td>0</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>T&lt;sub&gt;J&lt;/sub&gt; Module operating temperature range for 100,000 hours lifetime</td>
<td>–40</td>
<td>110</td>
<td>°C</td>
</tr>
</tbody>
</table>

(1) The module operating temperature range includes module self temperature rise and IC junction temperature rise. In applications where high power dissipation is present, the maximum operating temperature or maximum output current must be derated. For applications where the module operates continuously at 125 °C temperature, the maximum lifetime is reduced to 50,000 hours.

6.4 Thermal Information

<table>
<thead>
<tr>
<th>THERMAL METRIC</th>
<th>TPS82130 (JEDEC 51-5)</th>
<th>TPS82130EVM-720</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&lt;sub&gt;BJA&lt;/sub&gt; Junction-to-ambient thermal resistance</td>
<td>58.2</td>
<td>46.1</td>
<td>°C/W</td>
</tr>
<tr>
<td>R&lt;sub&gt;BJ(C)&lt;/sub&gt; Junction-to-case (top) thermal resistance</td>
<td>9.4</td>
<td>9.4</td>
<td>°C/W</td>
</tr>
<tr>
<td>R&lt;sub&gt;JB&lt;/sub&gt; Junction-to-board thermal resistance</td>
<td>14.4</td>
<td>14.4</td>
<td>°C/W</td>
</tr>
<tr>
<td>Ψ&lt;sub&gt;JT&lt;/sub&gt; Junction-to-top characterization parameter</td>
<td>0.9</td>
<td>0.9</td>
<td>°C/W</td>
</tr>
<tr>
<td>Ψ&lt;sub&gt;JB&lt;/sub&gt; Junction-to-board characterization parameter</td>
<td>14.2</td>
<td>14.0</td>
<td>°C/W</td>
</tr>
<tr>
<td>R&lt;sub&gt;BJ(C)&lt;/sub&gt; Junction-to-case (bottom) thermal resistance</td>
<td>21.3</td>
<td>21.3</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report. Theta-JA can be improved with a custom PCB design containing thermal vias where possible.
6.5 Electrical Characteristics

$T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ and $V_{\text{IN}} = 3.0$ V to $17$ V. Typical values are at $T_J = 25^\circ\text{C}$ and $V_{\text{IN}} = 12$ V, 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>$I_Q$</td>
<td>Quiescent current into $V_{\text{IN}}$</td>
<td>No load, device not switching</td>
<td>20</td>
<td>35</td>
<td>µA</td>
</tr>
<tr>
<td>$I_{\text{SD}}$</td>
<td>Shutdown current into $V_{\text{IN}}$</td>
<td>EN = Low</td>
<td>1.5</td>
<td>7.4</td>
<td>µA</td>
</tr>
<tr>
<td>$V_{\text{UVLO}}$</td>
<td>Undervoltage lockout threshold</td>
<td>$V_{\text{IN}}$ falling</td>
<td>2.6</td>
<td>2.7</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{\text{IN}}$ rising</td>
<td>2.8</td>
<td>2.9</td>
<td>3.0</td>
</tr>
<tr>
<td>$T_{\text{JSD}}$</td>
<td>Thermal shutdown threshold</td>
<td>$T_J$ rising</td>
<td>160</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_J$ falling</td>
<td>140</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

**LOGIC INTERFACE (EN)**

<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>$V_{\text{IH}}$</td>
<td>High-level input voltage</td>
<td></td>
<td>0.9</td>
<td>0.65</td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{IL}}$</td>
<td>Low-level input voltage</td>
<td></td>
<td>0.45</td>
<td>0.3</td>
<td>V</td>
</tr>
<tr>
<td>$I_{\text{ILKG(EN)}}$</td>
<td>Input leakage current into the EN pin</td>
<td>EN = High</td>
<td>0.01</td>
<td>1</td>
<td>µA</td>
</tr>
</tbody>
</table>

**CONTROL (SS/TR, PG)**

<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>$I_{\text{SS/TR}}$</td>
<td>SS/TR pin source current</td>
<td></td>
<td>2.1</td>
<td>2.5</td>
<td>2.8</td>
</tr>
<tr>
<td>$V_{\text{PG}}$</td>
<td>Power-good threshold</td>
<td>$V_{\text{OUT}}$ rising, referenced to $V_{\text{OUT}}$ nominal</td>
<td>92%</td>
<td>95%</td>
<td>99%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{\text{OUT}}$ falling, referenced to $V_{\text{OUT}}$ nominal</td>
<td>87%</td>
<td>90%</td>
<td>94%</td>
</tr>
<tr>
<td>$V_{\text{PG,OL}}$</td>
<td>Power-good low-level voltage</td>
<td>$I_{\text{sink}} = 2$ mA</td>
<td>0.1</td>
<td>0.3</td>
<td>V</td>
</tr>
<tr>
<td>$I_{\text{ILKG(PG)}}$</td>
<td>Input leakage current into the PG pin</td>
<td>$V_{\text{PG}} = 1.8$ V</td>
<td>1</td>
<td>400</td>
<td>nA</td>
</tr>
</tbody>
</table>

**OUTPUT**

<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>$V_{\text{FB}}$</td>
<td>Feedback regulation voltage</td>
<td>PWM mode</td>
<td>785</td>
<td>800</td>
<td>815</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$T_J = 0^\circ\text{C}$ to $85^\circ\text{C}$</td>
<td>788</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PSM</td>
<td>785</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$C_{\text{OUT}} = 22$ µF, $T_J = 0^\circ\text{C}$ to $85^\circ\text{C}$</td>
<td>785</td>
<td>800</td>
</tr>
<tr>
<td>$I_{\text{ILKG(FB)}}$</td>
<td>Feedback input leakage current</td>
<td>$V_{\text{FB}} = 0.8$ V</td>
<td>1</td>
<td>100</td>
<td>nA</td>
</tr>
<tr>
<td>Line regulation</td>
<td>$I_{\text{OUT}} = 1$ A, $V_{\text{OUT}} = 1.8$ V</td>
<td></td>
<td>0.002</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Load regulation</td>
<td>$I_{\text{OUT}} = 0.5$ A to 3 A, $V_{\text{OUT}} = 1.8$ V</td>
<td></td>
<td>0.12</td>
<td>%</td>
<td></td>
</tr>
</tbody>
</table>

**POWER SWITCH**

<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>$R_{\text{DS(on)}}$</td>
<td>High-side FET on-resistance</td>
<td>$I_{\text{SW}} = 500$ mA, $V_{\text{IN}} \geq 6$ V</td>
<td>90</td>
<td>170</td>
<td>mΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_{\text{SW}} = 500$ mA, $V_{\text{IN}} = 3$ V</td>
<td>120</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low-side FET on-resistance</td>
<td>$I_{\text{SW}} = 500$ mA, $V_{\text{IN}} \geq 6$ V</td>
<td>40</td>
<td>70</td>
<td>mΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_{\text{SW}} = 500$ mA, $V_{\text{IN}} = 3$ V</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_{\text{DOP}}$</td>
<td>Dropout resistance</td>
<td>100% mode, $V_{\text{IN}} \geq 6$ V</td>
<td>125</td>
<td>160</td>
<td>mΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100% mode, $V_{\text{IN}} = 3$ V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{\text{IMF}}$</td>
<td>High-side FET switch current limit</td>
<td>$V_{\text{IN}} = 6$ V, $T_A = 25^\circ\text{C}$</td>
<td>3.6</td>
<td>4.2</td>
<td>4.9</td>
</tr>
<tr>
<td>$f_{\text{SW}}$</td>
<td>PWM switching frequency</td>
<td>$I_{\text{OUT}} = 1$ A, $V_{\text{OUT}} = 1.8$ V</td>
<td></td>
<td>2.0</td>
<td>MHz</td>
</tr>
</tbody>
</table>
6.6 Typical Characteristics

Figure 6-1. Dropout Resistance

Figure 6-2. Quiescent Current

Figure 6-3. Shutdown Current
7 Detailed Description

7.1 Overview

The TPS82130 synchronous step-down converter MicroSiP power module is based on DCS-Control (Direct Control with Seamless transition into power save mode). This is an advanced regulation topology that combines the advantages of hysteretic and voltage mode control.

The DCS-Control topology operates in PWM (pulse width modulation) mode for medium to heavy load conditions and in PSM (power save mode) at light load currents. In PWM mode, the converter operates with its nominal switching frequency of 2.0 MHz having a controlled frequency variation over the input voltage range. As the load current decreases, the converter enters power save mode, reducing the switching frequency and minimizing the quiescent current of the IC to achieve high efficiency over the entire load current range. DCS-Control supports both operation modes using a single building block and therefore has a seamless transition from PWM to PSM without effects on the output voltage. The TPS82130 offers excellent DC voltage regulation and load transient regulation, combined with low output voltage ripple, minimizing interference with RF circuits.

7.2 Functional Block Diagram

7.3 Feature Description

7.3.1 PWM and PSM Operation

The TPS82130 includes an on-time (t\textsubscript{ON}) circuitry. t\textsubscript{ON}, in steady-state operation in PWM and PSM modes, is estimated as:

\[ t_{ON} = 500\text{ns} \times \frac{V_{OUT}}{V_{IN}} \]  

(1)

In PWM mode, the TPS82130 operates with pulse width modulation in continuous conduction mode (CCM) with a t\textsubscript{ON} shown in Equation 1 at medium and heavy load currents. A PWM switching frequency of typically 2.0 MHz...
is achieved by this \( t_{ON} \) circuitry. The device operates in PWM mode as long as the output current is higher than half of the ripple current of the inductor estimated by Equation 2.

\[
\Delta L = t_{ON} \times \frac{V_{IN} - V_{OUT}}{L}
\]  

(2)

To maintain high efficiency at light loads, the device enters power save mode seamlessly when the load current decreases. This happens when the load current becomes smaller than half of the ripple current of the inductor. In PSM, the converter operates with reduced switching frequency and with a minimum quiescent current to maintain high efficiency. PSM is also based on the \( t_{ON} \) circuitry. The switching frequency in PSM is estimated as:

\[
t_{PSM} = \frac{2 \times I_{OUT}}{t_{ON}^2} \times \frac{V_{IN}}{V_{OUT}} \times \frac{V_{IN} - V_{OUT}}{L}
\]  

(3)

In PSM, the output voltage rises slightly above the nominal output voltage in PWM mode. This effect is reduced by increasing the output capacitance. The output voltage accuracy in PSM operation is reflected in Section 6.5 and given for a 22-µF output capacitor.

For very small output voltages, an absolute minimum on time of approximately 80 ns is kept to limit switching losses. The operating frequency is thereby reduced from its nominal value, which keeps efficiency high. Also, the off time can reach its minimum value at high duty cycles. The output voltage remains regulated in such cases.

When \( V_{IN} \) decreases to typically 15% above \( V_{OUT} \), the TPS82130 cannot enter power save mode, regardless of the load current. The device maintains output regulation in PWM mode.

### 7.3.2 Low Dropout Operation (100% Duty Cycle)

The TPS82130 offers a low input to output voltage differential by entering 100% duty cycle mode. In this mode, the high-side MOSFET switch is constantly turned on. This is particularly useful in battery powered applications to achieve the longest operation time by taking full advantage of the whole battery voltage range. The minimum input voltage to maintain a minimum output voltage is given by:

\[
V_{IN(\text{min})} = V_{OUT(\text{min})} + I_{OUT} \times R_{DP}
\]  

(4)

where

- \( R_{DP} \) = Resistance from \( V_{IN} \) to \( V_{OUT} \), including high-side FET on-resistance and DC resistance of the inductor
- \( V_{OUT(\text{min})} \) = Minimum output voltage the load can accept

### 7.3.3 Switch Current Limit

The switch current limit prevents the device from high inductor current and from drawing excessive current from the battery or input voltage rail. Excessive current can occur with a heavy load/shorted output circuit condition. If the inductor peak current reaches the switch current limit after a propagation delay of typically 30 ns, the high-side FET is turned off and the low-side FET is turned on to ramp down the inductor current.

### 7.3.4 Undervoltage Lockout

To avoid mis-operation of the device at low input voltages, an undervoltage lockout is implemented, which shuts down the device at voltages lower than \( V_{\text{UVLO}} \) with a hysteresis of 200 mV.

### 7.3.5 Thermal Shutdown

The device goes into thermal shutdown and stops switching once the junction temperature exceeds \( T_{JSD} \). Once the device temperature falls below the threshold by 20°C, the device returns to normal operation automatically.
7.4 Device Functional Modes

7.4.1 Enable and Disable (EN)

The device is enabled by setting the EN pin to a logic High. Accordingly, shutdown mode is forced if the EN pin is pulled Low with a shutdown current of typically 1.5 μA.

An internal 400-kΩ pulldown resistor is connected to the EN pin when the EN pin is Low. The pulldown resistor is disconnected when the EN pin is High.

7.4.2 Soft Start-Up (SS/TR)

The internal voltage clamp controls the output voltage slope during start-up. This avoids excessive inrush current and ensures a controlled output voltage rise time. When the EN pin is pulled high, the device starts switching after a delay of typically 55 μs and the output voltage rises with a slope controlled by an external capacitor connected to the SS/TR pin. Using a very small capacitor or leaving the SS/TR pin floating provides the fastest start-up time.

The TPS82130 is able to start into a pre-biased output capacitor. During the pre-biased start-up, both the power MOSFETs are not allowed to turn on until the internal voltage clamp sets an output voltage above the pre-bias voltage.

When the device is in shutdown, undervoltage lockout, or thermal shutdown, the capacitor connected to the SS/TR pin is discharged by an internal resistor. Returning from those states causes a new start-up sequence.

7.4.3 Voltage Tracking (SS/TR)

The SS/TR pin is externally driven by another voltage source to achieve output voltage tracking. The application circuit is shown in Figure 7-1.

![Figure 7-1. Output Voltage Tracking](image)

When the SS/TR pin voltage is between 50 mV and 1.2 V, the VOUT2 tracks the VOUT1 as described in Equation 5.

\[
\frac{V_{\text{OUT2}}}{V_{\text{OUT1}}} = 0.64 \times \frac{R_2}{R_1+R_2} \times \frac{R_3+R_4}{R_4}
\]

When the SS/TR pin voltage is above 1.2 V, the voltage tracking is disabled and the FB pin voltage is regulated at 0.8 V. To decrease the SS/TR pin voltage, the device does not sink current from the output, so the resulting decreases of the output voltage can be slower than the SS/TR pin voltage if the load is light. When driving the SS/TR pin with an external voltage, do not exceed the voltage rating of the SS/TR pin which is VIN + 0.3 V.

Details about tracking and sequencing circuits are found in the Sequencing and Tracking With the TPS621-Family and TPS821-Family Application Report.
7.4.4 Power-Good Output (PG)

The device has a power-good (PG) output. The PG pin goes high impedance once the output is above 95% of the nominal voltage, and is driven low once the output voltage falls below typically 90% of the nominal voltage. The PG pin is an open-drain output and is specified to sink up to 2 mA. The power good output requires a pullup resistor connecting to any voltage rail less than 6 V.

The PG signal can be used for sequencing of multiple rails by connecting it to the EN pin of other converters. Leave the PG pin floating when it is not used. Table 7-1 shows the PG pin logic.

<table>
<thead>
<tr>
<th>DEVICE STATE</th>
<th>PG LOGIC STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable (EN=High)</td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;FB&lt;/sub&gt; ≥ V&lt;sub&gt;TH_PG&lt;/sub&gt;</td>
<td>√</td>
</tr>
<tr>
<td>V&lt;sub&gt;FB&lt;/sub&gt; ≤ V&lt;sub&gt;TH_PG&lt;/sub&gt;</td>
<td></td>
</tr>
<tr>
<td>Shutdown (EN = Low)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>√</td>
</tr>
<tr>
<td>UVLO</td>
<td></td>
</tr>
<tr>
<td>0.7 V &lt; V&lt;sub&gt;IN&lt;/sub&gt; &lt; V&lt;sub&gt;UVLO&lt;/sub&gt;</td>
<td>√</td>
</tr>
<tr>
<td>Thermal Shutdown</td>
<td></td>
</tr>
<tr>
<td>T&lt;sub&gt;J&lt;/sub&gt; &gt; T&lt;sub&gt;SD&lt;/sub&gt;</td>
<td>√</td>
</tr>
<tr>
<td>Power Supply Removal</td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;IN&lt;/sub&gt; &lt; 0.7 V</td>
<td>√</td>
</tr>
</tbody>
</table>

Table 7-1. Power Good Pin Logic
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, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

The output voltage of the TPS82130 is adjusted by component selection. The following section discusses the design of the external components to complete the power supply design for several input and output voltage options by using typical applications as a reference.

8.2 Typical Applications

8.2.1 1.8-V Output Application

![Diagram of 1.8-V Output Application](image)

Figure 8-1. 1.8-V Output Application

8.2.1.1 Design Requirements

For this design example, use the following as the input parameters.

<table>
<thead>
<tr>
<th>DESIGN PARAMETER</th>
<th>EXAMPLE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage range</td>
<td>12 V</td>
</tr>
<tr>
<td>Output voltage</td>
<td>1.8 V</td>
</tr>
<tr>
<td>Output ripple voltage</td>
<td>&lt; 20 mV</td>
</tr>
<tr>
<td>Output current rating</td>
<td>3 A</td>
</tr>
</tbody>
</table>

The components used for measurements are given in the following table.

<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>DESCRIPTION</th>
<th>MANUFACTURER</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>10 µF, 25 V, X7R, ±20%, size 1206, C3216X7R1E106M160AE</td>
<td>TDK</td>
</tr>
<tr>
<td>C2</td>
<td>22 µF, 10 V, ±20%, X7S, size 0805, C2012X7S1A226M125AC</td>
<td>TDK</td>
</tr>
<tr>
<td>C3</td>
<td>3300 pF, 50 V, ±5%, C0G/NP0, size 0603, GRM1885C1H332JA01D</td>
<td>Murata</td>
</tr>
<tr>
<td>R1, R2, R3</td>
<td>Standard</td>
<td></td>
</tr>
</tbody>
</table>
8.2.1.2 Detailed Design Procedure

8.2.1.2.1 Custom Design with WEBENCH® Tools

Click here to create a custom design using the TPS82130 device with the WEBENCH® Power Designer.

1. Start by entering your \( V_{IN} \), \( V_{OUT} \), and \( I_{OUT} \) requirements.
2. Optimize your design for key parameters like efficiency, footprint and cost using the optimizer dial and compare this design with other possible solutions from Texas Instruments.
3. The WEBENCH Power Designer provides you with a customized schematic along with a list of materials with real time pricing and component availability.
4. In most cases, you will also be able to:
   • Run electrical simulations to see important waveforms and circuit performance
   • Run thermal simulations to understand the thermal performance of your board
   • Export your customized schematic and layout into popular CAD formats
   • Print PDF reports for the design, and share your design with colleagues
5. Get more information about WEBENCH tools at www.ti.com/WEBENCH.

8.2.1.2.2 Setting the Output Voltage

The output voltage is set by an external resistor divider according to Equation 6:

\[
V_{OUT} = V_{FB} \times \left( 1 + \frac{R1}{R2} \right) = 0.8 \times \left( 1 + \frac{R1}{R2} \right)
\]  

(6)

R2 should not be higher than 100 kΩ to achieve high efficiency at light load while providing acceptable noise sensitivity. Larger currents through R2 improve noise sensitivity and output voltage accuracy. Figure 8-1 shows the external resistor divider value for a 1.8-V output. Choose appropriate resistor values for other outputs.

In case the FB pin gets opened, the device clamps the output voltage at the VOUT pin internally to approximately 7 V.

8.2.1.2.3 Input and Output Capacitor Selection

For the best output and input voltage filtering, low-ESR ceramic capacitors are required. The input capacitor minimizes input voltage ripple, suppresses input voltage spikes, and provides a stable system rail for the device. A 10-µF or larger input capacitor is required. The output capacitor value can range from 22 µF up to more than 400 µF. Higher values are possible as well and can be evaluated through the transient response. Larger soft start times are recommended for higher output capacitances.

High capacitance ceramic capacitors have a DC bias effect, which will have a strong influence on the final effective capacitance. Therefore the right capacitor value has to be chosen carefully. Package size and voltage rating in combination with dielectric material are responsible for differences between the rated capacitor value and the effective capacitance.

8.2.1.2.4 Soft Start-Up Capacitor Selection

A capacitance connected between the SS/TR pin and the GND allows programming the start-up slope of the output voltage. A constant current of 2.5 µA charges the external capacitor. The capacitance required for a given soft start-up time for the output voltage is given by:

\[
C_{SS/TR} = \frac{I_{SS/TR}}{I_{1.25V}}
\]  

(7)
8.2.1.3 Application Performance Curves

\( T_A = 25^\circ C, V_{IN} = 12 \text{ V}, V_{OUT} = 1.8 \text{ V}, \) unless otherwise noted.

Figure 8-2. Efficiency, \( V_{OUT} = 1 \text{ V} \)

Figure 8-3. Efficiency, \( V_{OUT} = 1.0 \text{ V} \)

Figure 8-4. Efficiency, \( V_{OUT} = 1.8 \text{ V} \)

Figure 8-5. Efficiency, \( V_{OUT} = 1.8 \text{ V} \)

Figure 8-6. Efficiency, \( V_{OUT} = 2.5 \text{ V} \)

Figure 8-7. Efficiency, \( V_{OUT} = 2.5 \text{ V} \)
Figure 8-8. Efficiency, \( V_{\text{OUT}} = 3.3 \) V

Figure 8-9. Efficiency, \( V_{\text{OUT}} = 3.3 \) V

Figure 8-10. Efficiency, \( V_{\text{OUT}} = 5.0 \) V

Figure 8-11. Efficiency, \( V_{\text{OUT}} = 5 \) V

Figure 8-12. Thermal Derating, \( V_{\text{OUT}} = 1.8 \) V

Figure 8-13. Thermal Derating, \( V_{\text{OUT}} = 3.3 \) V
Figure 8-14. Thermal Derating, $V_{OUT} = 1.0\, V$

Figure 8-15. Load Regulation

Figure 8-16. Line Regulation

Figure 8-17. Switching Frequency

Figure 8-18. Switching Frequency

Figure 8-19. Input and Output Ripple in PWM Mode
Figure 8-20. Input and Output Ripple in PSM Mode

Figure 8-21. Load Transient

Figure 8-22. Load Transient

Figure 8-23. Startup without Load

Figure 8-24. Startup / Shutdown with Resistance Load
9 Power Supply Recommendations

The devices are designed to operate from an input voltage supply range between 3 V and 17 V. The average input current of the TPS82130 is calculated as:

$$I_{IN} = \frac{1}{\eta} \frac{V_{OUT} \times I_{OUT}}{V_{IN}}$$

Ensure that the power supply has a sufficient current rating for the applications.
10 Layout

10.1 Layout Guidelines

- TI recommends placing all components as close as possible to the IC. The input capacitor placement specifically must be closest to the VIN and GND pins of the device.
- Use wide and short traces for the main current paths to reduce the parasitic inductance and resistance.
- To enhance heat dissipation of the device, the exposed thermal pad should be connected to bottom or internal layer ground planes using vias.
- Refer to Figure 10-1 for an example of component placement, routing, and thermal design.

10.2 Layout Example

![Figure 10-1. TPS82130 PCB Layout](image)

10.3 Thermal Consideration

The output current of the TPS82130 needs to be derated when the device operates in a high ambient temperature or delivers high output power. The amount of current derating is dependent upon the input voltage, output power, PCB layout design, and environmental thermal condition. Care should especially be taken in applications where the localized PCB temperature exceeds 65°C.

The TPS82130 module temperature must be kept less than the maximum rating of 125°C. Three basic approaches for enhancing thermal performance are below:

- Improve the power dissipation capability of the PCB design.
- Improve the thermal coupling of the TPS82130 to the PCB.
- Introduce airflow into the system.

To estimate approximate module temperature of TPS82130, apply the typical efficiency stated in this data sheet to the desired application condition to find the power dissipation of the module. Then, calculate the module temperature rise by multiplying the power dissipation by its thermal resistance. For more details on how to use the thermal parameters in real applications, see the *Thermal Characteristics of Linear and Logic Packages Using JEDEC PCB Designs Application Report* and *Semiconductor and IC Package Thermal Metrics Application Report*. 
11 Device and Documentation Support

11.1 Device Support

11.1.1 Development Support

11.1.1.1 Third-Party Products Disclaimer

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11.1.1.2 Custom Design with WEBENCH® Tools

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   • Export your customized schematic and layout into popular CAD formats
   • Print PDF reports for the design, and share your design with colleagues
5. Get more information about WEBENCH tools at www.ti.com/WEBENCH.

11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on

 ti.com. Click on Subscribe to updates 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.

11.3 Support Resources

TI E2E™ support forums are an engineer’s go-to source for fast, verified answers and design help — straight
from the experts. Search existing answers or ask your own question to get the quick design help you need.

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11.5 Glossary

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

11.6 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled
with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may
be more susceptible to damage because very small parametric changes could cause the device not to meet its published
specifications.
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.
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. Pick and place nozzle $\geq 1.3$ mm or smaller recommended.
4. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

www.ti.com
NOTES: (continued)

5. 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).
SIL0008D
MicroSiP™ - 1.53 mm max height
MICRO SYSTEM IN PACKAGE

SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
EXPOSED PAD
85% PRINTED SOLDER COVERAGE BY AREA
SCALE:30X

NOTES: (continued)

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

**REEL DIMENSIONS**

- Reel Diameter

**TAPE DIMENSIONS**

- K0
- P1
- B0
- W
- A0

<table>
<thead>
<tr>
<th>Quadrant Assignments for Pin 1 Orientation in Tape</th>
</tr>
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<tbody>
<tr>
<td>Q1</td>
</tr>
<tr>
<td>Q3</td>
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</tbody>
</table>

**Pocket Quadrants**

- Sprocket Holes

**User Direction of Feed**

<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>
<th>Pin1 Quadrant</th>
</tr>
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<tbody>
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<td>TPS82130SILR</td>
<td>uSiP</td>
<td>SIL</td>
<td>8</td>
<td>3000</td>
<td>330.0</td>
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<td>3.25</td>
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<td>8.0</td>
<td>12.0</td>
<td>Q1</td>
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<td>Width (mm)</td>
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</table>
### PACKAGING INFORMATION

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<thead>
<tr>
<th>Orderable Device</th>
<th>Status (1)</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>Package Qty</th>
<th>Eco Plan (2)</th>
<th>Lead finish/ Ball material</th>
<th>MSL Peak Temp (3)</th>
<th>Op Temp (°C)</th>
<th>Device Marking (4/5)</th>
<th>Samples</th>
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<tbody>
<tr>
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<td>Level-2-260C-1 YEAR</td>
<td>-40 to 125</td>
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<td>Samples</td>
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<td>H6</td>
<td>Samples</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) **RoHS**: TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

- **RoHS Exempt**: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

- **Green**: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(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 Finish/Ball material - Orderable Devices 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.

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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.
### TAPE AND REEL INFORMATION

#### TAPE DIMENSIONS

- **A0**: Dimension designed to accommodate the component width
- **B0**: Dimension designed to accommodate the component length
- **K0**: Dimension designed to accommodate the component thickness
- **W**: Overall width of the carrier tape
- **P1**: Pitch between successive cavity centers

#### REEL DIMENSIONS

*All dimensions are nominal.*

<table>
<thead>
<tr>
<th>Device</th>
<th>Package Type</th>
<th>Package Drawing</th>
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Pack Materials-Page 1
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*All dimensions are nominal.*
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