

## Features

- 16-V to 170-V Input Voltage Range
- Selectable 12-V, 15-V, and 18-V Output Voltages
- Programmable Output Voltage
- 0.8-A Output Current Capability
- High-Voltage Startup
- High Efficiency with PFM Mode at Light Loads
- 12-ms Soft Startup Time
- 100-kHz Switching Frequency
- VDD Under-voltage Protection
- Over Load Protection
- Output Short-circuit Protection
- Cycle-by-cycle Current Limit
- Operating  $T_J$  Range from  $-40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$
- Available in the SOP8 Package

## Applications

- PoE
- E-Bike
- E-Tools
- Scotter
- Solar Inverter

## Description

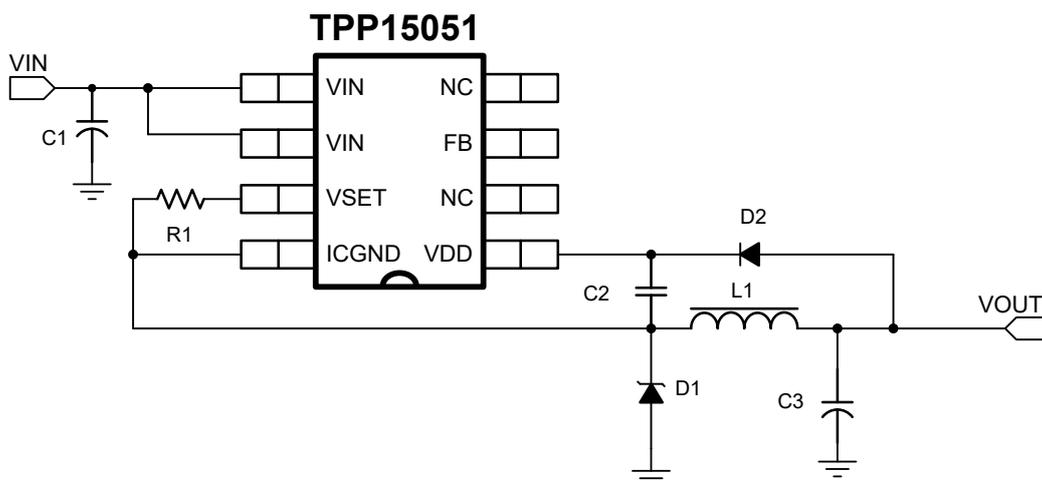
The TPP15051 is a wide input range, non-synchronous DC-DC buck converter that uses peak current mode control. The TPP15051 integrates a 170-V, 1.3- $\Omega$  power MOSFET with 1.5-A peak current limit having up to 0.8-A output current capability.

The TPP15051 has a high-voltage startup circuitry to enable the device from high input voltage directly. The TPP15051 has a built-in 12-ms soft-start time to minimize the inrush current during startup. In the moderate to heavy load condition, the TPP15051 works in PWM mode at 100-kHz switching frequency. In the light load condition, the TPP15051 enters PFM mode to reduce the switching loss and improve the efficiency. The TPP15051 also has spread spectrum switching frequency dithering to reduce the EMI.

The TPP15051 features a cycle-by-cycle current limit in over-load conditions. Furthermore, when the output voltage is 10% below the regulation target and the current limit is touched for 128 switching cycles, or the output is short to ground, the TPP15051 enters hiccup mode and stops PWM switching for 65 ms. After hiccup times out, the TPP15051 re-starts the soft startup.

The TPP15051 is available in the SOP8 package.

## Typical Application Circuit



## Table of Contents

|   |           |
|---|-----------|
| <b>Features</b> .....                         | <b>1</b>  |
| <b>Applications</b> .....                     | <b>1</b>  |
| <b>Description</b> .....                      | <b>1</b>  |
| <b>Typical Application Circuit</b> .....      | <b>1</b>  |
| <b>Product Family Table</b> .....             | <b>3</b>  |
| <b>Revision History</b> .....                 | <b>3</b>  |
| <b>Pin Configuration and Functions</b> .....  | <b>4</b>  |
| <b>Specifications</b> .....                   | <b>5</b>  |
| Absolute Maximum Ratings <sup>(1)</sup> ..... | 5         |
| ESD, Electrostatic Discharge Protection.....  | 5         |
| Recommended Operating Conditions.....         | 5         |
| Thermal Information.....                      | 5         |
| Electrical Characteristics.....               | 6         |
| Typical Performance Characteristics.....      | 8         |
| <b>Detailed Description</b> .....             | <b>11</b> |
| Overview.....                                 | 11        |
| Functional Block Diagram.....                 | 11        |
| Feature Description.....                      | 11        |
| <b>Application and Implementation</b> .....   | <b>14</b> |
| Application Information .....                 | 14        |
| Typical Application.....                      | 14        |
| Application Examples.....                     | 15        |
| <b>Layout</b> .....                           | <b>16</b> |
| Layout Guideline.....                         | 16        |
| Layout Example.....                           | 16        |
| <b>Tape and Reel Information</b> .....        | <b>17</b> |
| <b>Package Outline Dimensions</b> .....       | <b>18</b> |
| SOP8.....                                     | 18        |
| <b>Order Information</b> .....                | <b>19</b> |
| <b>IMPORTANT NOTICE AND DISCLAIMER</b> .....  | <b>20</b> |

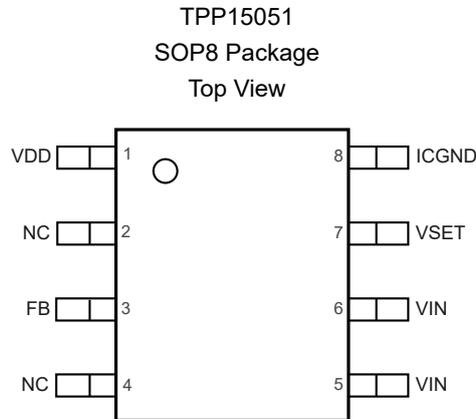
## Product Family Table

| Part Number | Feature        | Package |
|-------------|----------------|---------|
| TPP15051    | Buck Converter | SOP8    |

## Revision History

| Date       | Revision | Notes                                 |
|------------|----------|---------------------------------------|
| 2025-10-27 | Rev.A.0  | Initial release                       |
| 2026-02-12 | Rev.A.1  | Updated the typical efficiency curves |

## Pin Configuration and Functions



**Table 1. Pin Functions: TPP15051**

| Pin |       | I/O/P | Description  |
|-----|-------|-------|--|
| No. | Name  |       |  |
| 1   | VDD   | P     | Power supply for the internal control circuitry  |
| 2,4 | NC    | -     | No connection  |
| 3   | FB    | I     | The feedback input of the output voltage when using an external feedback resistor divider. When using internal fixed output settings, leave the FB pin floating or connect it to the ICGND pin.  |
| 5,6 | VIN   | I     | Drain of the switch MOSFET   |
| 7   | VSET  | P     | Output voltage setting pin. Leave the VSET pin floating to select the fixed 12-V output voltage. Connect the VSET pin to the ICGND pin to select the fixed 15-V output voltage. Connect a 51-k $\Omega$ resistor between the VSET pin and the ICGND pin to select the fixed 18-V output voltage. Connect a 150-k $\Omega$ resistor between the VSET pin and the ICGND pin to set the output voltage by an external resistor divider. |
| 8   | ICGND | I     | Source of the switch MOSFET. This pin is also the ground of the device   |

## Specifications

### Absolute Maximum Ratings <sup>(1)</sup>

| Parameter                  |                                     | Min  | Max | Unit |
|----------------------------|-------------------------------------|------|-----|------|
| Voltage Range at Terminals | V <sub>IN</sub>                     | -0.3 | 180 | V    |
|                            | V <sub>DD</sub>                     | -0.3 | 26  | V    |
|                            | V <sub>SET</sub> , FB               | -0.3 | 6   | V    |
| T <sub>J</sub>             | Maximum Junction Temperature        | -40  | 150 | °C   |
| T <sub>A</sub>             | Operating Temperature Range         | -40  | 125 | °C   |
| T <sub>STG</sub>           | Storage Temperature Range           | -65  | 150 | °C   |
| T <sub>L</sub>             | Lead Temperature (Soldering 10 sec) |      | 260 | °C   |

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

### ESD, Electrostatic Discharge Protection

| Parameter        |                          | Condition                             | Minimum Level | Unit |
|------------------|--------------------------|---------------------------------------|---------------|------|
| V <sub>HBM</sub> | Human Body Model ESD     | ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup> | 2000          | V    |
| V <sub>CDM</sub> | Charged Device Model ESD | ANSI/ESDA/JEDEC JS-002 <sup>(2)</sup> | 500           | V    |

(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.

### Recommended Operating Conditions

| Parameter        |  | Min | Typ | Max  | Unit |
|------------------|--|-----|-----|------|------|
| V <sub>IN</sub>  | Power Supply   | 16  |     | 170  | V    |
| V <sub>OUT</sub> | Output Voltage                                       | 3.3 |     | 50   | V    |
| C <sub>OUT</sub> | Effective Capacitance for Each Buck Converter Output | 220 | 470 | 1000 | μF   |
| L                | Inductor for Each Buck Converter                     | 47  | 220 | 470  | μH   |
| T <sub>J</sub>   | Junction Temperature Range                           | -40 |     | 125  | °C   |

### Thermal Information

| Package Type | θ <sub>JA</sub> | θ <sub>JB</sub> | θ <sub>JC(TOP)</sub> | Unit |
|--------------|-----------------|-----------------|----------------------|------|
| SOP8         | 109.0           | 80.3            | 54.1                 | °C/W |

## Electrical Characteristics

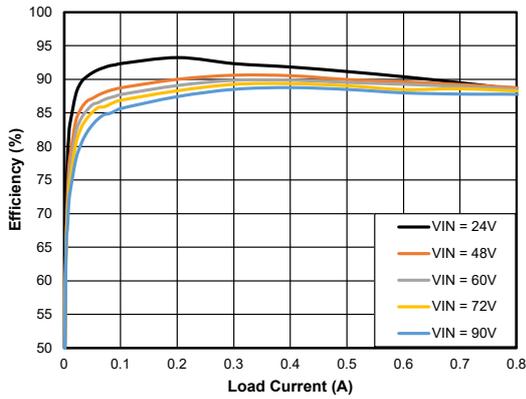
All test conditions:  $V_{IN} = 48\text{ V}$ ,  $V_{DD} = 12\text{ V}$ ,  $T_J = -40^\circ\text{C}$  to  $125^\circ\text{C}$ , unless otherwise noted. Typical values are at  $T_J = 25^\circ\text{C}$ .

| Symbol                                | Parameter                                 | Conditions                                       | Min   | Typ       | Max   | Unit          |
|---------------------------------------|---|--|-------|-----------|-------|---------------|
| <b>VIN Supply Voltage and Current</b> |   |  |       |           |       |               |
| $V_{IN}$                              | IC Supply Voltage Range                   |  | 16    |           | 170   | V             |
| $I_{HVC}$                             | High Voltage Operating Quiescent Current  | $V_{DD} = 0\text{ V}$ , $V_{IN} = 150\text{ V}$  |       | 4         |       | mA            |
| $I_{HVS}$                             | High Voltage Shutdown Current             | $V_{DD} = 18\text{ V}$ , $V_{IN} = 150\text{ V}$ |       | 6         |       | $\mu\text{A}$ |
| <b>VDD Regulator</b>                  |   |  |       |           |       |               |
| $V_{DD}$                              | VDD Voltage Range                         | After startup                                    | 6.5   |           | 21    | V             |
| $I_{DD}$                              | Quiescent Current                         | Switching mode                                   |       | 0.9       |       | mA            |
| $V_{DD\_C}$                           | VDD Internal Charging Termination Voltage |  |       | 9.5       |       | V             |
| $V_{DD\_UVLO}$                        | VDD UVLO Rising Threshold                 |  | 7.5   | 8         | 8.5   | V             |
| $V_{DD\_UVLO\_HYS}$                   | VDD UVLO Hysteresis                       |  |       | 2         |       | V             |
| $V_{DD\_CLMP}$                        | VDD Clamp Voltage                         | $I_{DD\_CLMP} = 10\text{ mA}$                    | 21    | 22.5      | 24    | V             |
| $I_{DD\_CLMP}$                        | VDD Sinking Current at Clamp Voltage      |  | 8     | 10        |       | mA            |
| <b>Reference Voltage</b>              |   |  |       |           |       |               |
| $V_{REF}$                             | Reference Voltage at the FB Pin           | $T_J = -40^\circ\text{C} - 125^\circ\text{C}$    | 0.965 | 1.01      | 1.045 | V             |
| <b>Power MOSFET Switch</b>            |   |  |       |           |       |               |
| $R_{DSON\_N}$                         | N-channel 180-V MOSFET on-Resistance      |  |       | 1.3       |       | $\Omega$      |
| $I_{LIM}$                             | Peak Current Limit                        |  | 1.0   | 1.5       | 2.0   | A             |
| $I_{SW\_LKG}$                         | N-channel MOSFET Leakage Current          | $V_{DD} = 5\text{ V}$ , $V_{IN} = 150\text{ V}$  |       | 6         |       | $\mu\text{A}$ |
| <b>Soft Start</b>                     |   |  |       |           |       |               |
| $t_{SS}$                              | Soft Startup Time                         |  |       | 12        |       | ms            |
| <b>Hiccup Time</b>                    |   |  |       |           |       |               |
| $t_{HICCUP}$                          | Hiccup Delay Time                         |  |       | 65        |       | ms            |
| <b>Switching Frequency</b>            |   |  |       |           |       |               |
| $f_{SW}$                              | Switching Frequency                       |  | 75    | 100       | 125   | kHz           |
| $\Delta f_{DITHER}$                   | Switching Frequency Dithering Range       |  |       | $\pm 6\%$ |       |               |
| $t_{MIN\_OFF}$                        | Minimum OFF Time                          |  |       | 500       |       | ns            |
| $t_{MIN\_ON}$                         | Minimum ON Time                           |  |       | 500       |       | ns            |
| <b>Thermal Protection</b>             |   |  |       |           |       |               |

| Symbol              | Parameter                             | Conditions                                   | Min | Typ | Max | Unit |
|---------------------|---------------------------------------|--|-----|-----|-----|------|
| T <sub>SD</sub>     | Thermal Shutdown Protection Threshold | T <sub>J</sub> rising                        |     | 175 |     | °C   |
| T <sub>SD_HYS</sub> | Thermal Shutdown Hysteresis           | T <sub>J</sub> falling below T <sub>SD</sub> |     | 25  |     | °C   |

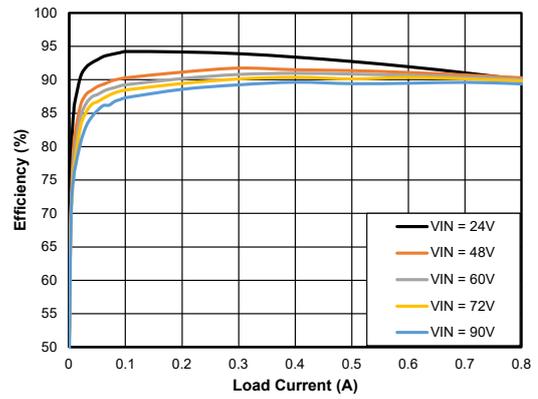
Typical Performance Characteristics

All test conditions:  $V_{IN} = 48\text{ V}$ ,  $V_{DD} = 12\text{ V}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.



$V_{OUT} = 12\text{ V}$

Figure 1. Efficiency vs. Load Current



$V_{OUT} = 15\text{ V}$

Figure 2. Efficiency vs. Load Current

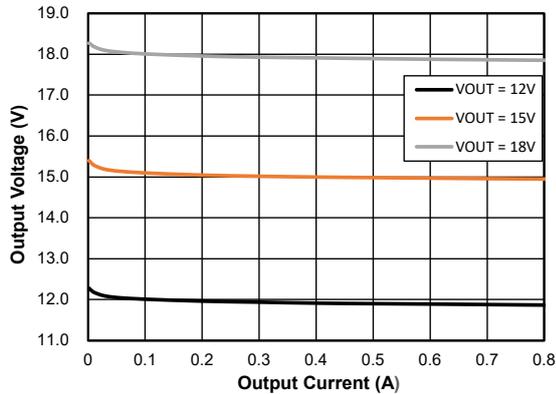


Figure 3. Output Voltage vs. Load Current

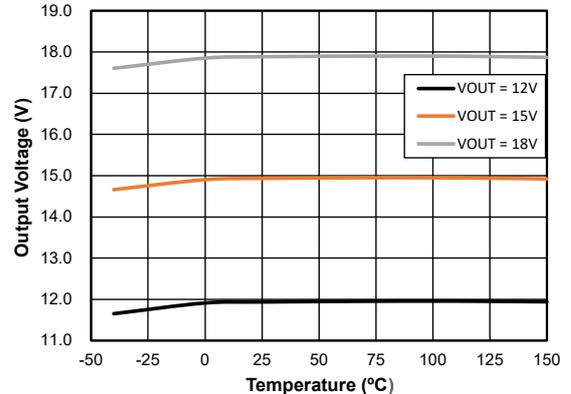


Figure 4. Output Voltage vs. Temperature

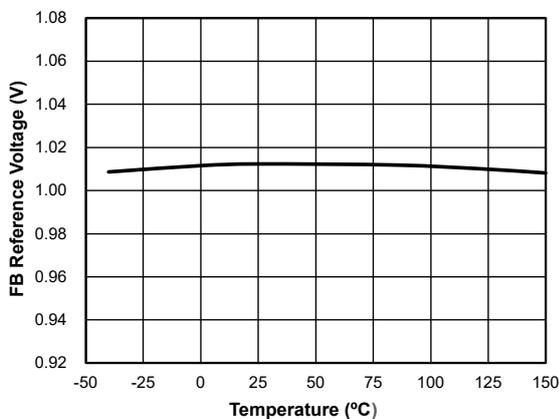


Figure 5. FB Reference Voltage vs. Temperature

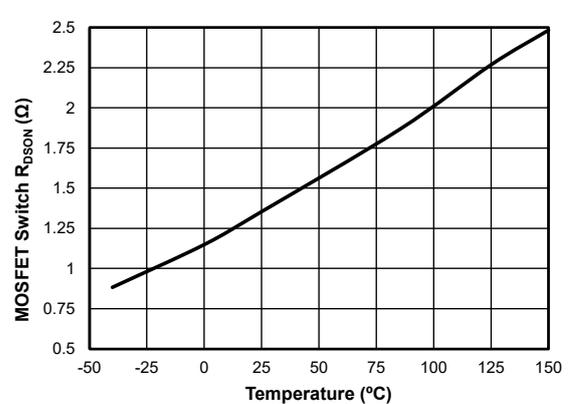


Figure 6. Rdson vs. Temperature

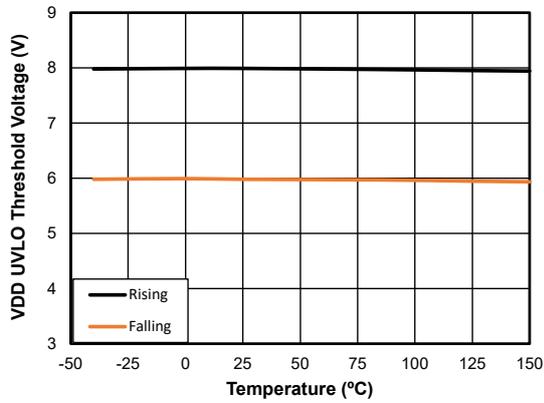


Figure 7. VDD UVLO vs. Temperature

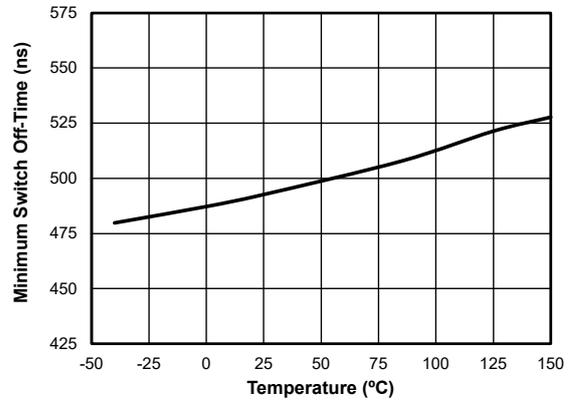


Figure 8. Minimum OFF Time vs. Temperature

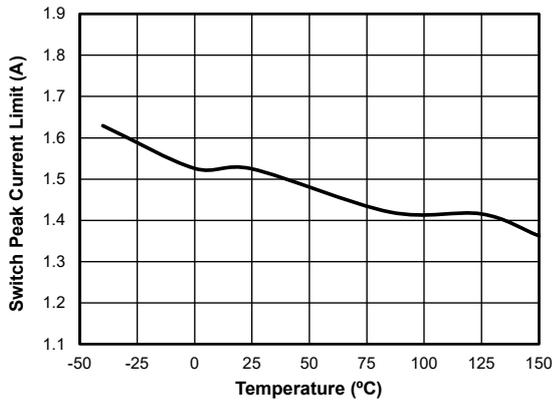


Figure 9. Current Limit vs. Temperature

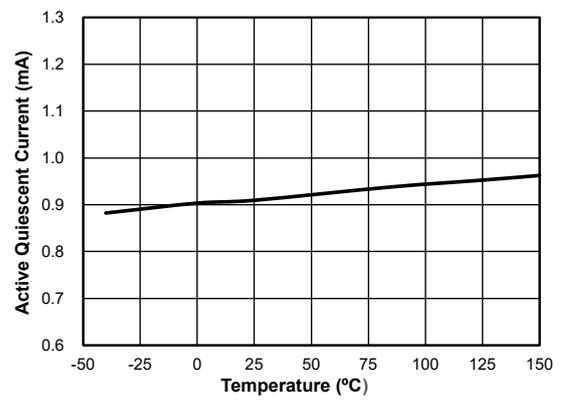


Figure 10. Quiescent Current vs. Temperature

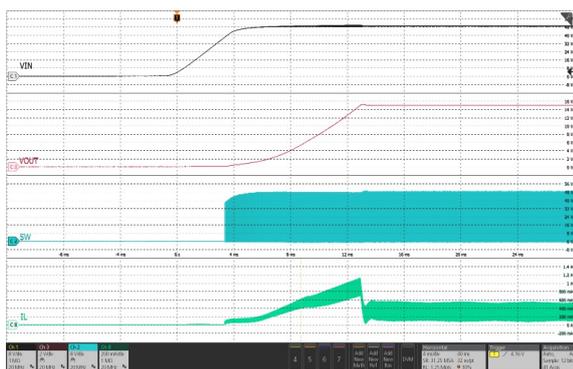
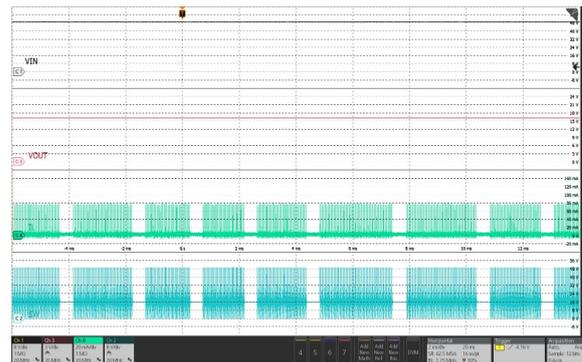
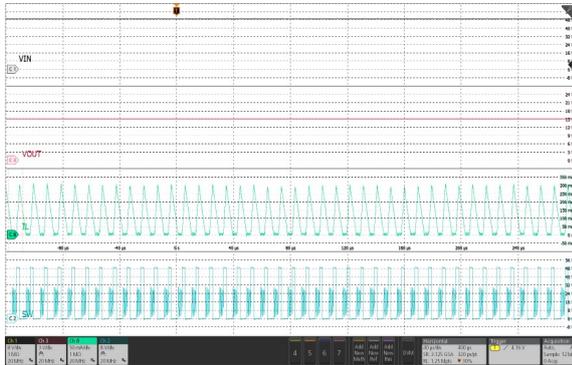


Figure 11. Startup Waveform



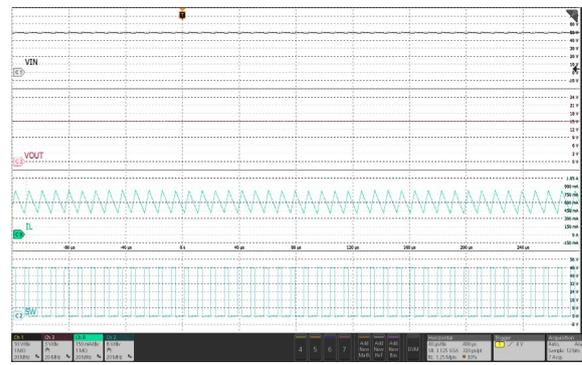
$V_{IN} = 48\text{ V}$ ,  $V_{OUT} = 15\text{ V}$ ,  $I_{OUT} = 0.7\text{ mA}$

Figure 12. Switching Waveform in Hiccup Mode



$V_{IN} = 48\text{ V}$ ,  $V_{OUT} = 15\text{ V}$ ,  $I_{OUT} = 100\text{ mA}$

**Figure 13. Switching Waveform in DCM Mode**



$V_{IN} = 48\text{ V}$ ,  $V_{OUT} = 15\text{ V}$ ,  $I_{OUT} = 600\text{ mA}$

**Figure 14. Switching Waveform in CCM Mode**

## Detailed Description

### Overview

The TPP15051 is a wide input range, non-synchronous DC-DC buck converter that uses peak current mode control. The TPP15051 integrates a 170-V, 1.3-Ω power MOSFET with 1.5-A peak current limit having up to 0.8-A output current capability.

The TPP15051 has a high-voltage startup circuitry to enable the device from high input voltage directly. The TPP15051 has a built-in 12-ms soft-start time to minimize the inrush current during startup. In the moderate to heavy load condition, the TPP15051 works in PWM mode at 100-kHz switching frequency. In the light load condition, the TPP15051 enters PFM mode to reduce the switching loss and improve efficiency. The TPP15051 also has spread spectrum switching frequency dithering to reduce the EMI.

### Functional Block Diagram

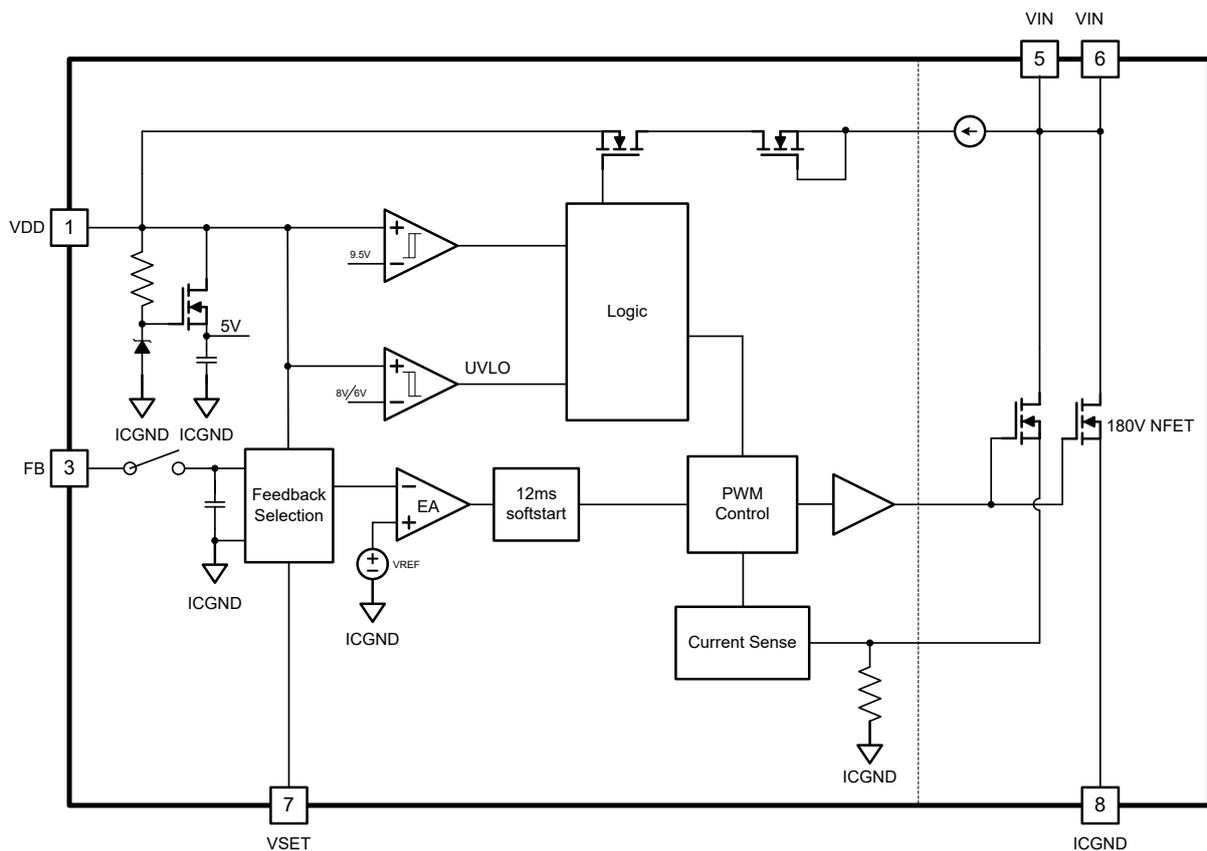


Figure 15. Functional Block Diagram

## Feature Description

### High Voltage Startup and VDD UVLO

The TPP15051 integrates a high-voltage startup circuitry. When the VIN pin is applied with a voltage above 16 V, an internal current source starts charging the capacitor at the VDD pin to 9.5 V. When the VDD voltage is above the UVLO rising

threshold of 8 V, the device starts switching. The power switch between the VIN pin and the ICGND pin is turned on and the current goes from the VIN pin to the ICGND pin.

When the VDD voltage is below 6 V, the TPP15051 is disabled.

### Soft Startup

The TPP15051 has a built-in 12-ms soft start time. When the PWM switching starts, the output of the internal error amplifier increases slowly. The current of the power switch is limited to eliminate the inrush current during startup. During the soft startup, the hiccup mode is disabled. Once the output voltage is above 95% of the regulation voltage or a 32-ms timer for soft startup times out, the hiccup mode is enabled.

### PWM mode and PFM Mode

In moderate to heavy load, the TPP15051 works in PWM mode. The switching frequency is fixed at 100 kHz. As the load decreases, the PWM switching operation goes from CCM mode to DCM mode.

At the light load, the PWM duty cycle goes to a minimum on-time limit as the load current decreases. The TPP15051 enters PFM mode. The switching frequency gradually changes from 100 kHz to 35 kHz to regulate the output voltage. When the switching frequency reaches 35 kHz but the load current continues decreasing, the output voltage goes up above the regulation voltage. To regulate the output voltage, the TPP15051 goes into hiccup mode and stops switching for 500  $\mu$ s. After a 500- $\mu$ s hiccup, the TPP15051 resumes switching without a soft start.

### Output Voltage Setting

The TPP15051 has preset 12-V, 15-V, and 18-V output voltage settings inside by connecting different resistances between the VSET pin and the ICGND pin as shown in [Table 2](#).

**Table 2. VOUT Setting by VSET Pin**

| VSET Connection                                  | VOUT  |
|--|---|
| VSET floating                                    | 12 V  |
| VSET connected to ICGND                          | 15 V  |
| 51-k $\Omega$ resistance between VSET and ICGND  | 18 V  |
| 150-k $\Omega$ resistance between VSET and ICGND | Adjustable VOUT set by an external resistor divider between VOUT and the ICGND pin. The FB pin is connected to the center tap of the resistor divider |

When using an external resistor divider to set the output voltage, the resistor divider is between the output voltage and the ICGND pin. It is recommended using less than 10-k resistance as the bottom resistor  $R_B$  between the FB pin and the ICGND pin. The upper resistor  $R_U$  between the FB pin and the output can be calculated by [Equation 1](#).

$$R_U = \left( \frac{V_{OUT} + V_D}{V_{REF}} - 1 \right) \times R_B \quad (1)$$

Where

- $V_D$  is the forward voltage of the rectifier schottky diode.
- $V_{REF}$  is the internal reference voltage.

### Dummy Load

A minimum load is needed to prevent the output voltage running away to high voltage when the load current is too small. When the system powered by the TPP15051 may consume very small power in some conditions like standby mode, a

dummy load is needed. However, a large dummy load increases the power loss in system standby condition. For 48-V input voltage and 15-V output voltage application, a 15-k $\Omega$  resistor is recommended at the output as the minimum load.

#### **Cycle-by-cycle Current Limit Protection**

When the current through the power switch trips 1.5 A, the power switch is turned off immediately. The power switch is kept off until the next switching cycle.

#### **Output Overload Protection**

After startup, when the output voltage is below the regulation voltage, the output of the internal error amplifier goes up to the high limit and the switch current hits the limit. When the output voltage is below 90% of the target regulation voltage and the current limit is reached for 128 switching cycles, the TPP15051 enters hiccup mode and stops switching for 65 ms. After a 65-ms hiccup period, the TPP15051 restarts the soft startup. If the output voltage rises above 90% of the target regulation voltage within the 128 switching cycles, the overload timer resets.

#### **Output Short-circuit Protection**

When the output short-circuit happens, the current through the power switch goes up above the cycle-by-cycle limit because the inductor current continues to increase within the minimum on-time period of each cycle. When the TPP15051 detects the current through the power switch more than 2.2 A (50% higher than the limit), the TPP15051 goes into hiccup mode and stop switching for 65 ms. After a 65-ms hiccup period, the TPP15051 restarts soft start.

#### **Thermal Shutdown Protection**

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 175°C. When the thermal shutdown is triggered, the device stops switching until the junction temperature falls below typically 150°C, then the device starts switching again.

## Application and Implementation

Note

Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

## Application Information

The TPP15051 is designed for outputting voltage from high input voltage up to 170 V. It adopts a peak current control scheme to achieve a fast transient response.

## Typical Application

48-V input to 15-V output buck converter.

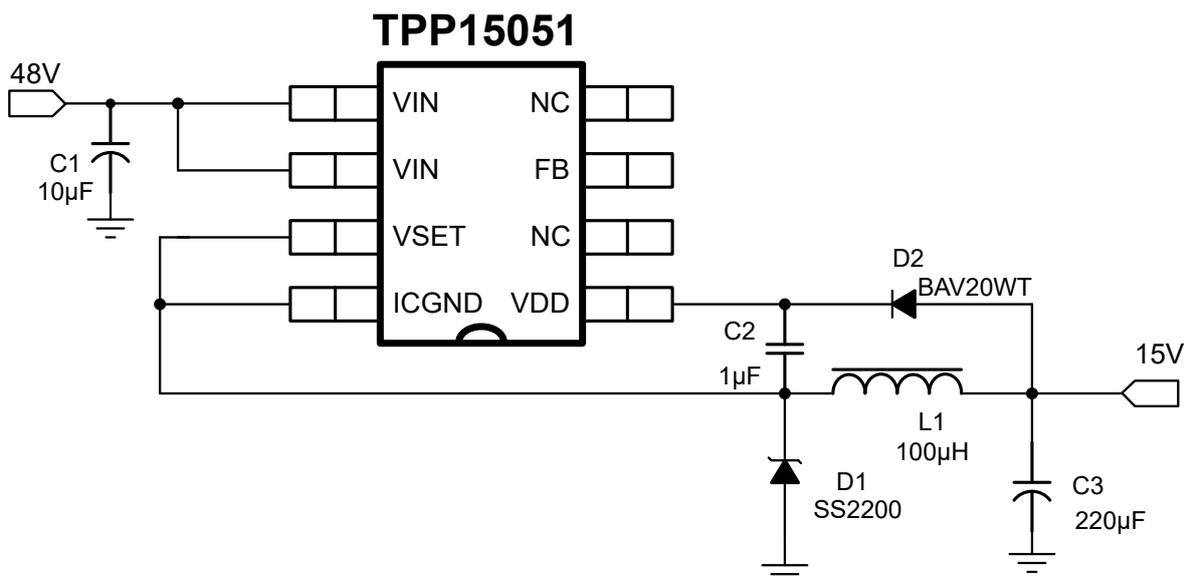


Figure 16. TPP15051 48-V to 15-V Buck Converter Application Circuit

## Application Examples

48-V input to 5-V output buck converter with the external voltage setting resistor divider.

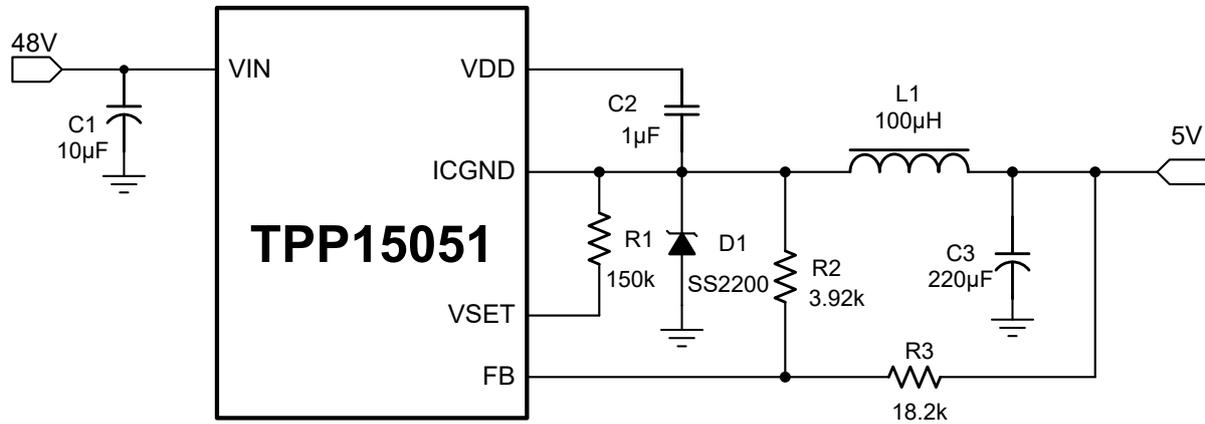


Figure 17. TPP15051 48-V to 5-V Buck Converter Application Circuit

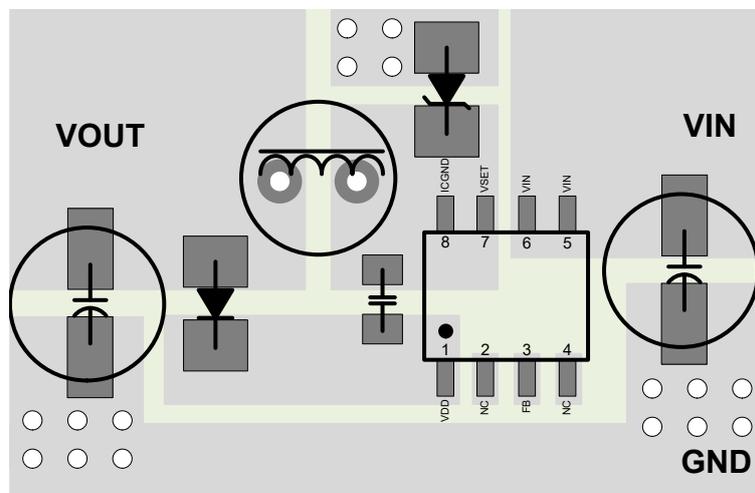
## Layout

### Layout Guideline

PCB layout is very critical for the performance of a DC to DC converter, especially for loop stability, EMI, and thermal performance. A good PCB layout with less parasitic inductance and capacitance results in a stable output voltage with less switching noise.

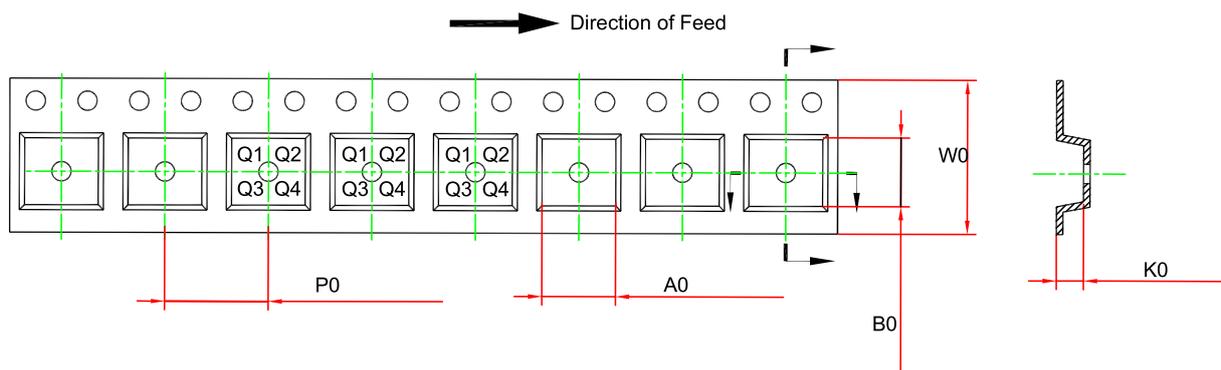
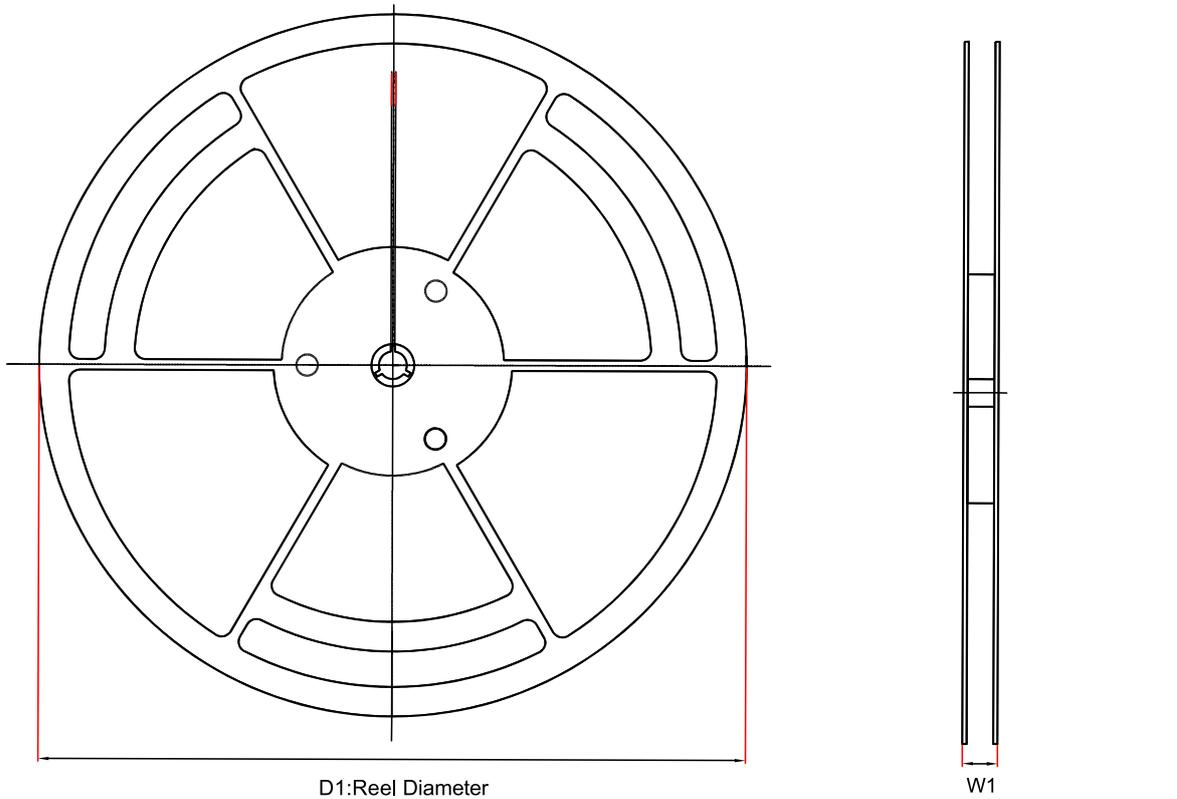
- Place the input bypass capacitor as close as possible to the VIN pin and the ground. Use short and wide trace to connect the input capacitor and the VIN pin. Care should be taken to minimize the loop area formed by the input bypass capacitor connections, the VIN pins, the ICGND pin, the external schottky diode and the ground connections.
- Since the ICGND connection is the switching node, the inductor should be located as close as possible to the ICGND pin. The area of the switching node connection must be kept small to minimize the EMI and the capacitive coupling between the ICGND node and the output.
- Use a low ESR ceramic capacitor as the boot capacitor between the VDD pin and the ICGND pin. The boot capacitor must also be located close to the VDD pin.
- When using an external resistor divider to set the output voltage, place the resistor divider as close as possible to the FB pin.

### Layout Example



**Figure 18. PCB Layout Example for 15-V Output Application**

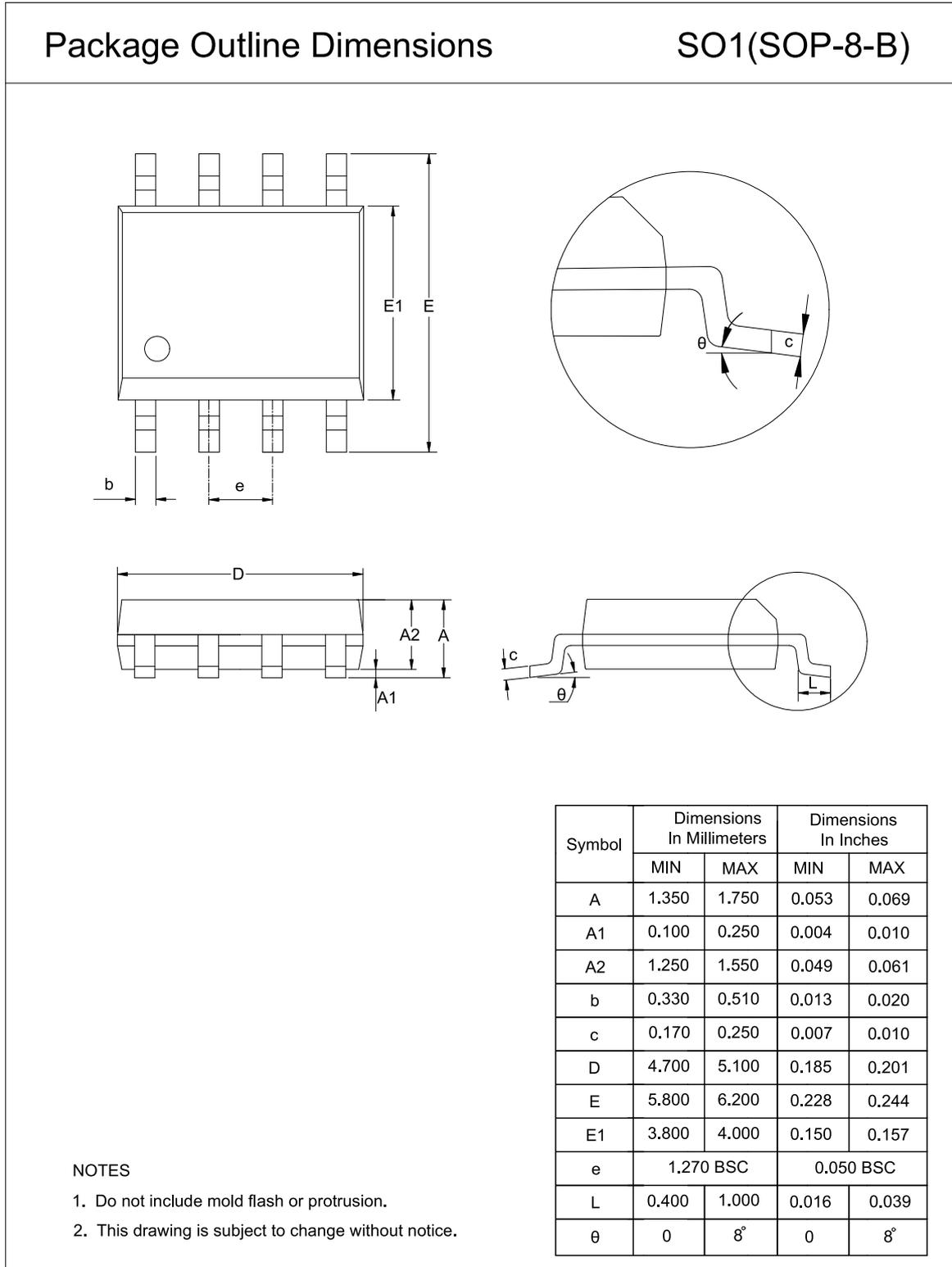
### Tape and Reel Information



| Order Number  | Package | D1 (mm) | W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P0 (mm) | W0 (mm) | Pin1 Quadrant |
|---------------|---------|---------|---------|---------|---------|---------|---------|---------|---------------|
| TPP15051-SO1R | SOP8    | 330     | 17.6    | 6.5     | 5.4     | 2       | 8       | 12      | Q1            |

Package Outline Dimensions

SOP8



## Order Information

| Order Number  | Operating Temperature Range | Package | Marking Information | MSL  | Transport Media, Quantity | Eco Plan |
|---------------|-----------------------------|---------|---------------------|------|---------------------------|----------|
| TPP15051-SO1R | -40 to 125°C                | SOP8    | 15051               | MSL3 | Tape & Reel, 4000         | Green    |

**Green:** 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

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