# TPS92201 1.5A High Efficiency Synchronous Buck LED Driver

## 1 Features

- 2.5V to 5.5V input voltage range
- 1.5A constant output current
- Up to 95% efficiency
- 0.1μA shutdown current
- 220mΩ (HS) / 170mΩ (LS) MOSFETs
- Up to 100% switching duty cycle
- 1.5MHz switching frequency
- Force PWM mode for low output ripple (TPS92201)
- Power save mode for high efficiency in light load (TPS92201A)
- 0.6V to VIN output voltage range
- 100mV feedback regulation voltage
- 1% to 100% analog dimming with high accuracy
- 20kHz to 200kHz PWM input frequency
- Internal soft startup
- Full protection with over current, LED open/short, FB resistor open/short
- Thermal shutdown protection
- WSON and SOT563 package options

## 2 Applications

- Test and measurement
- Power delivery
- Building automation
  - Smart home camera
  - Video doorbell
  - IP camera
  - Smart doorlock
  - Flashlight

## 3 Description

The TPS92201 is a high-efficiency 1.5A synchronous buck-type LED driver with 2.5V to 5.5V input range. By integrating the high-side and low-side MOSFET, high efficiency and compact solution size can be achieved. The ultra-low 1μA shutdown current helps saving power in battery-powered applications.

Adaptive off-time with peak current control scheme is adapted in the TPS92201. To get the smallest output ripple, the device operates at typically 1.5MHz pulse width modulation (PWM) mode in full current range.

Adaptive off-time with peak current control scheme is adapted in the TPS92201A. At medium to heavy load, the device operates in pulse width modulation (PWM) mode with 1.5MHz switching frequency. At light load, the device automatically enters pulse frequency modulation (PFM) to maintain high efficiency over the entire load current range.

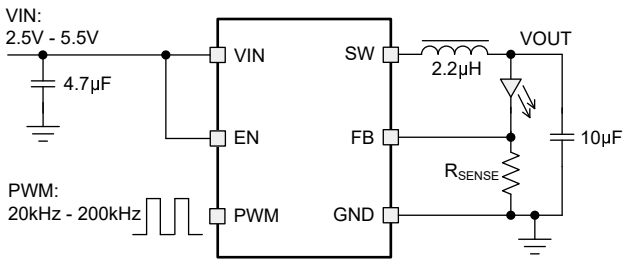
The integrated switches have the capability to deliever up to 1.5A constant current. Analog dimming is achieved by adjusting the duty cycle of the PWM input with 1% to 100% range. 20kHz to 200kHz input PWM frequency can be supported to avoid audible noise.

For safety and protection, the TPS92201 device implement full protections, including LED open, LED short, FB resistor open, FB resistor short and thermal shutdown.

**Device Information** (1)

| ORDERABLE PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|---|---|---|
| TPS92201DRV | WSON (6) | 2mm × 2mm (2) |
| TPS92201ADRV | WSON (6) | |
| TPS92201DRL | SOT563 (6) | 1.6mm × 1.6mm |
| TPS92201ADRL | SOT563 (6) | |

(1) For more information, see Section 11.
(2) The package size (length x width) is a nominal value and includes pins, where applicable.




**Simplified Schematic**

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## 4 Device Comparison Table

| PART NUMBER | MATERIAL | POWER SAVE MODE | PACKAGE |
|---|---|---|---|
| TPS92200 | TPS92201DRVR | No | WSON-6 |
| | TPS92201MDRVR(1) | | |
| | TPS92201DRLR | | SOT563-6 |
| | TPS92201MDRLR(1) | | |
| TPS92201A | TPS92201ADRVR | Yes | WSON-6 |
| | TPS92201AMDRVR(1) | | |
| | TPS92201ADRLR | | SOT563-6 |
| | TPS92201AMDRLR(1) | | |

(1) Extended Temperature devices, supporting –55°C to approximately 125°C operating ambient temperature.

# 5 Pin Configuration and Functions

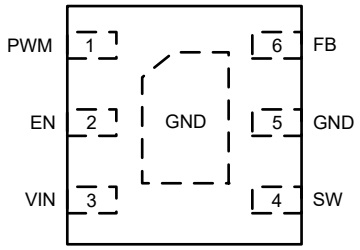



**Figure 5-1. DRV Package 6-Pin WSON Top View**

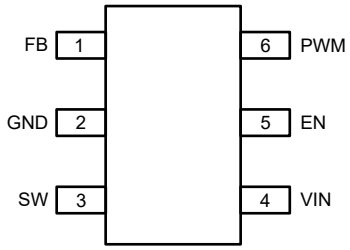



**Figure 5-2. DRL Package 6-Pin SOT563 Top View**

| PIN NUMBER | | | I/O/PWR | DESCRIPTION |
|---|---|---|---|---|
| NAME | DRV | DRL | | |
| PWM | 1 | 6 | I | PWM input. LED output current is adjusted according to the PWM input duty cycle. |
| EN | 2 | 5 | I | Device enable input. Logic high enables the device, logic low disables the device and turns the device into shutdown. Do not leave floating. |
| VIN | 3 | 4 | PWR | Power supply input. |
| SW | 4 | 3 | PWR | Switch pin. Connecting the internal FET switches and inductor terminal. |
| GND | 5 | 2 | PWR | Power ground. |
| FB | 6 | 1 | I | Feedback pin for the internal control loop. Connect this pin to an external resistor to set output current. |

# 6 Specifications

## 6.1 Absolute Maximum Ratings

over operating ambient temperature range (unless otherwise noted)(1)

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| Voltage | VIN, EN, PWM | –0.3 | 6 | V |
| | SW (DC) | –0.3 | VIN + 0.3 | V |
| | SW (AC, 10ns transient) | –3 | 9 | V |
| | FB | –0.3 | 5.5 | V |
| Operating junction temperature, $T_J$ | | –40 | 150 | °C |
| Storage temperature, $T_{stg}$ | | –65 | 150 | °C |

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

## 6.2 ESD Ratings

| | | | VALUE | UNIT |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1) | ±2000 | V |
| | | Charged-device model (CDM), per ANSI/ESDA/JEDEC JS-002(2) | ±500 | |

(1) JEDEC document JEP155 states that 500-V HBM allows safemanufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safemanufacturing with a standard ESD control process.

## 6.3 Recommended Operating Conditions

over operating ambient temperature range (unless otherwise noted)

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| Input stage | $V_{IN}$ | 2.5 | 5.5 | V |
| | $V_{EN}$ | –0.1 | 6 | V |
| | $V_{PWM}$ | –0.1 | 6 | V |
| Output stage | $V_{OUT}$ | | $V_{IN}$ | V |
| | $I_{OUT}$ | | 1.5 | A |
| Peripheral component | Effective inductance | 2.2 | 4.7 | µH |
| | Effective capacitance | | | µF |
| Temperature | Operating Ambient temperature, $T_A$ | -40 | 85 | °C |
| | Operating Junction temperature, $T_J$ | –40 | 125 | °C |

## 6.4 Thermal Information

| THERMAL METRIC(1) | | TPS92201, TPS92201A | | UNIT |
|---|---|---|---|---|
| | | DRL (SOT563) | DRV (WSON-6) | |
| | | 6 PINS | 6 PINS | |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 152 | 82.6 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 73.1 | 106.5 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 41.3 | 45.8 | °C/W |
| $\psi_{JT}$ | Junction-to-top characterization parameter | 2.1 | 7.7 | °C/W |
| $\psi_{JB}$ | Junction-to-board characterization parameter | 40.7 | 45.7 | °C/W |

(1) For more information about traditional and new thermalmetrics, see the *Semiconductor and IC Package Thermal Metrics*application report, SPRA953.

## 6.5 Electrical Characteristics

$V_{IN}$ = 2.5V to 5.5V, $T_A$ = –40°C to +85°C($T_A$ = –55°C to +125°C for TPS92201MDRVR and TPS92201AMDRVR and for the TPS92201MDRLR and TPS92201AMDRLR); Typical values are at $T_A$ = 25°C (unless otherwise specified)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **INPUT SUPPLY** | | | | | | |
| $V_{IN}$ | Input voltage range | | 2.5 | | 5.5 | V |
| $V_{IN\_UVLO}$ | $V_{IN}$ undervoltage lockout | Fallng $V_{IN}$ | 2.1 | 2.2 | | V |
| | | Rising $V_{IN}$ | | 2.3 | 2.4 | V |
| | Hysteresis | | | 0.1 | | V |
| $I_{SD}$ | Shutdown current into $V_{IN}$ | $V_{IN}$ = 3.6V, $V_{EN}$ = 0 | | 0.1 | 0.5 | µA |
| $I_{SD\_ET}$ | Shutdown current into $V_{IN}$ | $V_{IN}$ = 3.6V, $V_{EN}$ = 0 (TPS92201MDRVR,TPS92201AMDRVR, TPS92201MDRLR and TPS92201AMDRLR) | | 0.1 | 1.75 | µA |
| $I_Q$ | Quiescent current into $V_{IN}$ | $V_{IN}$ = 3.6V, $V_{EN}$ = 2V, $V_{FB}$=0V, Not switching (TPS92201) | 450 | 520 | 600 | µA |
| | | $V_{IN}$ = 3.6V, $V_{EN}$ = 2V, $V_{FB}$ = 0V, Not switching (TPS92201A) | 520 | 630 | 720 | µA |
| **LOGIC INTERFACE** | | | | | | |
| $V_{EN\_H}$ | High-level threshold voltage of EN | | | | 1.2 | V |
| $V_{EN\_L}$ | Low-level threshold voltage of EN | | 0.4 | | | V |
| $V_{IH\_PWM}$ | High-level threshold voltage of PWM | | | | 1 | V |
| $V_{IL\_PWM}$ | Low-level threshold voltage of PWM | | 0.7 | | | V |
| $t_{EN\_ON}$ | EN minimum on time to enable device | | | | | µS |
| $t_{EN\_OFF}$ | EN minimum off time to disable device | | | | | µS |
| $t_{PWM\_ON}$ | PWM minimum on time when dimming the output current | | | | 5 | µS |
| $f_{PWM}$ | PWM input frequency | | 20 | | 200 | kHz |
| $D_{PWM}$ | PWM input duty cycle | | 1 | | 100 | % |
| $I_{LKG}$ | Leakage current of EN pin | $V_{IN}$ = 5.5V, $V_{EN}$ = 5.5V, $V_{PWM}$ = 5.5V, | | | 1 | µA |
| $I_{LKG}$ | Leakage current of PWM pin | $V_{IN}$ = 5.5V, $V_{EN}$ = 5.5V, $V_{PWM}$ = 5.5V, | | | 0.5 | µA |
| **OUTPUT STAGE** | | | | | | |
| $V_{FB\_REF}$ | FB pin regulation voltage at maximum duty cycle | PWM = 100%, $I_{OUT}$ = 500mA | 92 | 100 | 104 | mV |
| | FB pin regulation voltage at 50% duty cycle | PWM = 50%, $I_{OUT}$ = 0mA(TM), $F_{PWM}$=20KHz | -8% | 50 | +8% | mV |
| | FB pin regulation voltage at 50% duty cycle | PWM = 50%, $I_{OUT}$ = 0mA(TM), $F_{PWM}$=200KHz | -10% | 50 | +10% | mV |
| | FB pin regulation voltage at 5% duty cycle | PWM = 5%, $I_{OUT}$ = 500mA | | 5 | | mV |
| | FB pin regulation voltage at 1% duty cycle | PWM = 1%, $I_{OUT}$ = 500mA | | 1 | | mV |
| $R_{HS}$ | High-side FET on resistance | | | 220 | 330 | mΩ |
| $R_{LS}$ | Low-side FET on resistance | | | 170 | 300 | mΩ |
| $f_{SW}$ | Switching frequency | | | 1.5 | | MHz |
| $D_{max}$ | Maximum switching duty cycle | | | 100 | | % |
| $I_{LIM\_HS}$ | High-side current limit | | 1.9 | 2.16 | | A |

## 6.6 Typical Characteristics

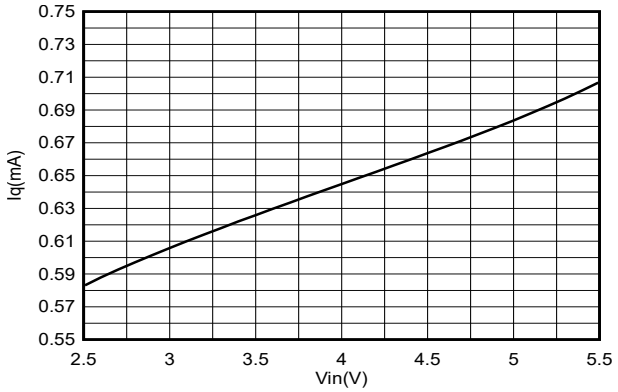



**Figure 6-1. Quiescent Current vs Input Voltage**

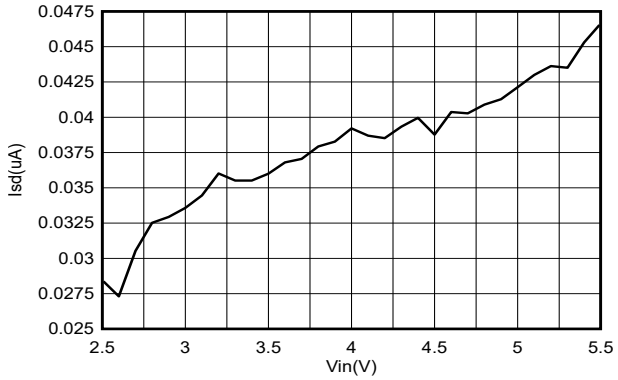



**Figure 6-2. Shutdown Current vs Input Voltage**

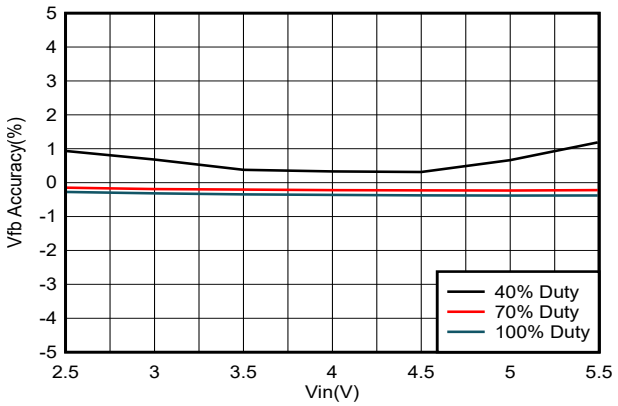



**Figure 6-3. FB Voltage Accuracy**

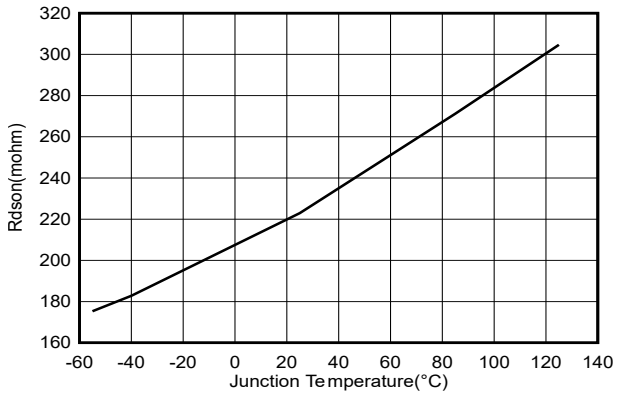



**Figure 6-4. High-Side FET On Resistance vs Junction Temperature**

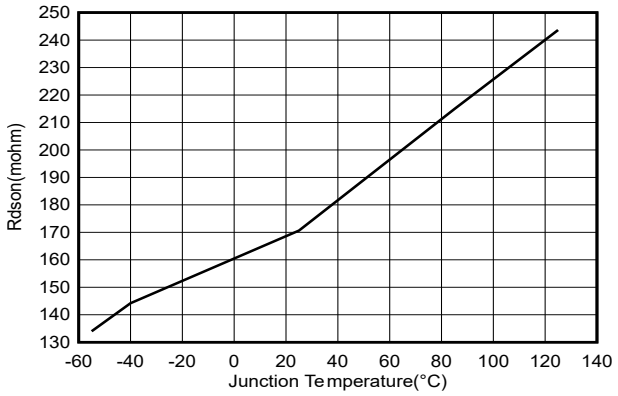



**Figure 6-5. Low-Side FET On Resistance vs Junction Temperature**

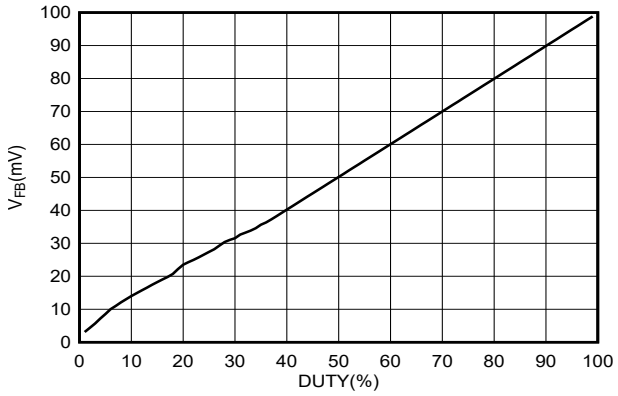



**Figure 6-6. PWM duty cycle vs FB voltage**

# 7 Detailed Description

## 7.1 Overview

The TPS92201 is a high-efficiency 1.5A synchronous buck-type LED driver with 2.5V to 5.5V input range. The device operates at typically 1.5MHz pulse width modulation (PWM) mode in full current range. In additional, TPS92201A can support Power Save Mode, the device operates in pulse width modulation (PWM) mode with 1.5MHz switching frequency at heavy load, similar as TPS92201. But at light load, the device automatically enters pulse frequency modulation (PFM) to maintain high efficiency over the entire load current range. In Power Save Mode, the converter reduces switching frequency and minimizes current consumption, the output voltage rises slightly above the nominal output voltage. This effect is minimized by increasing the output capacitor.

The integrated switches for both deivces have the capability to deliever up to 1.5A constant current and no need for external Schottky diode. Analog dimming is achieved by adjusting the duty cycle of the PWM in 1% to 100% range. Full protection methods are implemented including LED open, LED short, FB resistor open, FB resistor short and thermal shutdown.

## 7.2 Functional Block Diagram

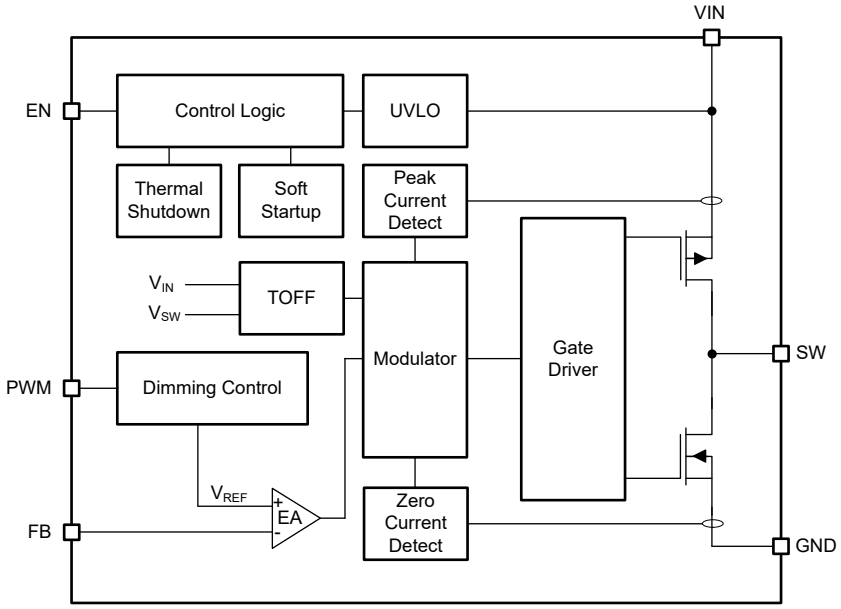



**Figure 7-1. TPS92201 Functional Block Diagram**

## 7.3 Feature Description

### *7.3.1 Adaptive Off-time Control*

Adaptive off-time with peak current control scheme is used in the device. The device operates at typically 1.5MHz pulse width modulation (PWM) mode in full current range. At medium to heavy load, the device operates in pulse width modulation (PWM) mode with 1.5MHz switching frequency. At light load, the device automatically enters pulse frequency modulation (PFM) to maintain high efficiency over the entire load current range. Based on the VIN/VOUT ratio, a simple circuit sets the required off time for the low-side MOSFET. The switching frequency relatively constant regardless of the variation of input voltage, output voltage, and load current.

### *7.3.2 Power Save Mode*

TPS92201A automatically enters Power Save Mode to improve efficiency at light load when the inductor current becomes discontinuous. In Power Save Mode, the converter reduces switching frequency and minimizes current consumption. In Power Save Mode, the output voltage rises slightly above the nominal output voltage. This effect is minimized by increasing the output capacitor.

### 7.3.3 Soft Startup

After enabling the device, internal soft startup circuitry ramps up the output voltage which reaches nominal output voltage during a startup time. Output current rises smoothly and excessive inrush current is avoided. In battery-power system, the soft startup prevents extra voltage drop on primary power supply with high internal impedance. The internal soft startup period is xx ms typically.

### 7.3.4 Low Dropout Operation

The device offers a low input-to-output voltage differential by entering 100% switching duty cycle mode. In this mode, the high-side MOSFET switch is constantly turned on and the low-side MOSFET is switched off. The minimum input voltage to maintain output regulation, depending on the load current and output voltage, is calculated as:

$$V_{IN\_MIN} = V_{FB} + V_{F\_IOUT} + I_{OUT} \times (R_{DS\_ON} + R_L) \quad (1)$$

where

- $V_{FB}$ is the feedback reference voltage, which is typically 100mV
- $V_{F\_IOUT}$ is the LED forward voltage at output current
- $I_{OUT}$ is the output current setting
- $R_{DS\_ON}$ is the high-side FET resistance when turning on
- $R_L$ is the inductor ohmic resistance DCR

### 7.3.5 LED Current Setting

The LED current is set by the external resistor between the FB pin and GND, calculated as:

$$I_{LED} = \frac{V_{FB}}{R_{SENSE}} \quad (2)$$

where

- $V_{FB}$ is the feedback reference voltage, which is typically 100mV
- $R_{SENSE}$ is the resistance between FB and GND

### 7.3.6 Voltage Reference

The feedback reference produces a precise ±5% voltage reference over whole temperature range when the PWM duty cycle is 100%, which is typically 100mV. In analog dimming mode, the feedback voltage is proportional to the duty cycle of PWM imput as shown in Figure 7-2.

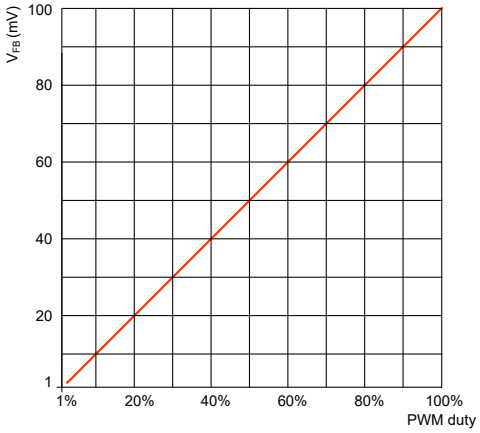



**Figure 7-2. FB voltage with PWM duty cycle**

### 7.3.7 Switch Current Limit

The switch current limit prevents the device from high inductor current and drawing excessive current from battery or input voltage supply. Excessive current might occur with a heavy load or shorted output circuit condition. The device adopts the peak current control by sensing the current of the high-side switch. Once the high-side switch current limit is reached, the high-side switch is turned off and low-side switch is turned on to discharge the inductor current with an adaptive off-time.

### 7.3.8 Fault Behaviors

The TPS92201 is protected by high-side current limitation in different fault conditions, such as LED open and short, sense resistor open and short. No matter the fault happens before startup or during operation, the device can stay safety.

**Table 7-1. Fault protection conditions**

| Fault | Condition | Behavior |
|---|---|---|
| LED open | $V_{FB}$ is driven close to 0 | VOUT keeps increasing to VIN. and The high-side switch keeps turn on. |
| LED anode short to cathode | $V_{FB}$ is driven to VOUT quickly, then | VFB is driven to VOUT quickly, the device keeps switching by minimum on-time. |
| LED anode short to GND | $V_{FB}$ is driven close to 0 | high-side switch current limit triggered |
| FB resistor open | $V_{FB}$ is driven to VOUT - Vf | The device keeps switching by the minimum on-time |
| FB short to GND | $V_{FB}$ is driven close to 0 | VFB is driven close to 0. Current limit is triggered. |

### 7.3.9 Under Voltage Lockout

To avoid mis-operation of the device at low input voltages, under voltage lockout is implemented that shuts down the device at voltages lower than $V_{UVLO}$ with $V_{HYS\_UVLO}$ hysteresis.

### 7.3.10 Thermal Shutdown

The device enters thermal shutdown once the junction temperature exceeds the thermal shutdown rising threshold, $T_{JSD}$. Once the junction temperature falls below the falling threshold, the device returns to normal operation automatically.

## 7.4 Device Functional Modes

### 7.4.1 Enabling/Disabling the Device

The device is enabled by setting the EN input to a logic High. Accordingly, a logic Low disables the device. If the device is enabled, the internal power stage starts switching and regulates the output current to the set value. The EN input must be terminated and should not be floating.

# 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 TPS92201 device is typically used as buck-type LED driver to drive IR or white LEDs from a 2.5V to 5.5V input.

## 8.2 Typical Application

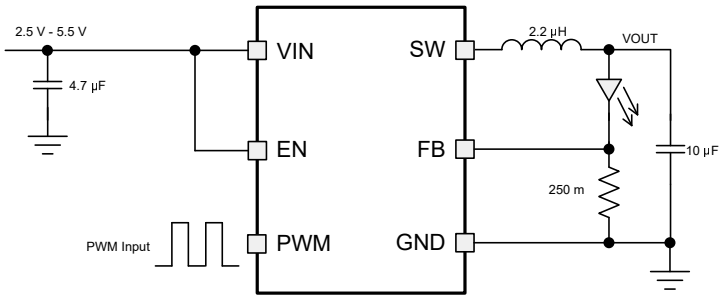



**Figure 8-1. TPS92201 400mA Output Application**

### *8.2.1 Design Requirements*

For this design example, use the parameters listed in Table 8-1 as the input parameters.

**Table 8-1. Design Parameters**

| DESIGN PARAMETER | EXAMPLE VALUE |
|---|---|
| Input voltage | 2.5V to 5.5V |
| Output voltage | 1.9V (1.8V Vf + 0.1V VFB) |
| Maximum output current | 400mA |

Table 8-2 lists the components used for the example.

**Table 8-2. List of Components**

| REFERENCE | DESCRIPTION | MANUFACTURER(1) |
|---|---|---|
| C1 | 4.7µF, Ceramic Capacitor, 10V, X7R, size 0805, GRM21BR71A475KA73L | Murata |
| C2 | 10µF, Ceramic Capacitor, 10V, X7R, size 0805, GRM21BR71A106KE51L | Murata |
| L1 | 2.2µH, Power Inductor, SDER041H-2R2MS | Cyntec |
| R1,R2,R3 | Chip resistor, 1%, size 0603 | Std. |
| C3 | Optional, 6.8pF if it is needed | Std. |

(1) See *Third-party Products Disclaimer*

### 8.2.2 Detailed Design Procedure

#### 8.2.2.1 Custom Design With WEBENCH® Tools

Click here to create a custom design using the TPS92201 device with the WEBENCH® Power Designer.

1. Start by entering the input voltage ($V_{IN}$), output voltage ($V_{OUT}$), and output current ($I_{OUT}$) requirements.
2. Optimize the design for key parameters such as efficiency, footprint, and cost using the optimizer dial.
3. Compare the generated design with other possible solutions from Texas Instruments.

The WEBENCH Power Designer provides a customized schematic along with a list of materials with real-time pricing and component availability.

In most cases, these actions are available:

- Run electrical simulations to see important waveforms and circuit performance
- Run thermal simulations to understand board thermal performance
- Export customized schematic and layout into popular CAD formats
- Print PDF reports for the design, and share the design with colleagues

Get more information about WEBENCH tools at www.ti.com/WEBENCH.

#### 8.2.2.2 Setting the Output Voltage

When sizing R2, in order to achieve low current consumption and acceptable noise sensitivity, use a maximum of 200kΩ for R2. Larger currents through R2 improve noise sensitivity and output voltage accuracy but increase current consumption.

$$V_{OUT} = V_{FB} \times \left(1 + \frac{R1}{R2}\right) = 0.6V \times \left(1 + \frac{R1}{R2}\right) \quad (3)$$

A feed forward capacitor, C3 improves the loop bandwidth to make a fast transient response. 6.8pF capacitance is recommended for R2 of 100kΩ resistance. A more detailed discussion on the optimization for stability vs. transient response can be found in SLVA289.

#### 8.2.2.3 Output Filter Design

The inductor and output capacitor together provide a low-pass filter. To simplify this process, Table 8-3 outlines possible inductor and capacitor value combinations. Checked cells represent combinations that are proven for stability by simulation and lab test. Further combinations should be checked for each individual application.

**Table 8-3. Matrix of Output Capacitor and Inductor Combinations**

| $V_{OUT}$ [V] | L [µH](1) | $C_{OUT}$ [µF](2) | | | | |
|---|---|---|---|---|---|---|
| | | 4.7 | 10 | 22 | 2x 22 | 100 |
| 0.6 ≤ $V_{OUT}$ < 1.2 | 1 | | | | + | |
| | 2.2 | | | | ++(3) | |
| 1.2 ≤ $V_{OUT}$ < 1.8 | 1 | | | + | + | |
| | 2.2 | | | ++(3) | + | |
| 1.8 ≤ $V_{OUT}$ | 1 | | + | + | + | |
| | 2.2 | | ++(3) | + | + | |

(1) Inductor tolerance and current de-rating is anticipated. The effective inductance can vary by +20% and -30%.
(2) Capacitor tolerance and bias voltage de-rating is anticipated. The effective capacitance can vary by +20% and -50%.
(3) This LC combination is the standard value and recommended for most applications.

#### 8.2.2.4 Inductor Selection

The main parameters for inductor selection is inductor value and then saturation current of the inductor. To calculate the maximum inductor current under static load conditions, Equation 4 is given:

$$I_{L,MAX} = I_{OUT,MAX} + \frac{\Delta I_L}{2}$$

$$\Delta I_L = V_{OUT} \times \frac{1 - \frac{V_{OUT}}{V_{IN}}}{L \times f_{SW}} \quad (4)$$

where:

- $I_{OUT,MAX}$ is the maximum output current
- $\Delta I_L$ is the inductor current ripple
- $f_{SW}$ is the switching frequency
- L is the inductor value

It is recommended to choose a saturation current for the inductor that is approximately 20% to 30% higher than $I_{L,MAX}$. In addition, DC resistance and size should also be taken into account when selecting an appropriate inductor.

#### 8.2.2.5 Input and Output Capacitor Selection

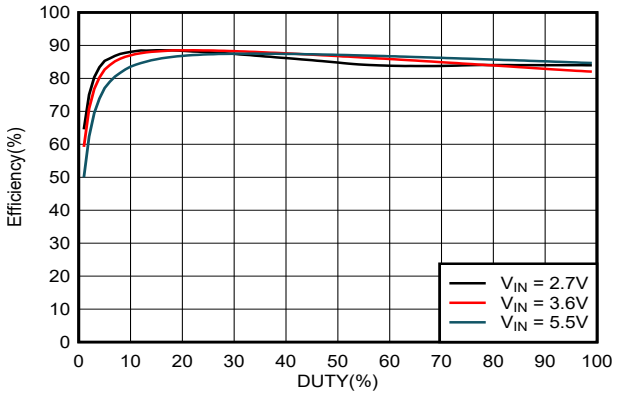
The architecture of the TPS92201 allows use of tiny ceramic-type output capacitors with low equivalent series resistance (ESR). These capacitors provide low output voltage ripple and are thus recommended. To keep its resistance up to high frequencies and to achieve narrow capacitance variation with temperature, it is recommended to use X7R or X5R dielectric.

The input capacitor is the low impedance energy source for the converter that helps provide stable operation. A low ESR multilayer ceramic capacitor is recommended for best filtering. For most applications, 4.7µF input capacitance is sufficient; a larger value reduces input voltage ripple.

The TPS92201 is designed to operate with an output capacitor of 10µF to 47µF, as outlined in Table 8-3.

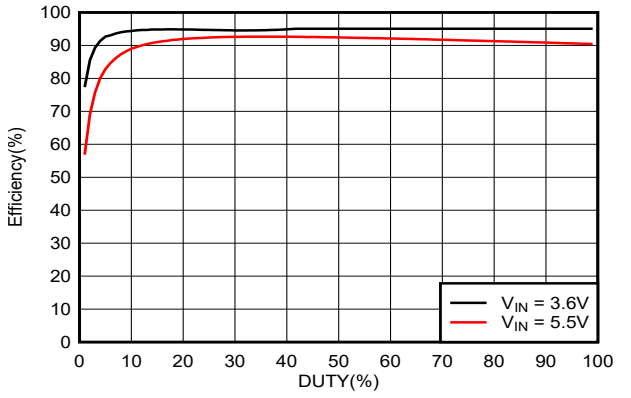
### 8.2.3 Application Performance Curves

$V_{IN}$ = 5V, $V_{OUT}$ = 1.8V, L = 2.2µH, $T_A$ = 25°C, unless otherwise noted.



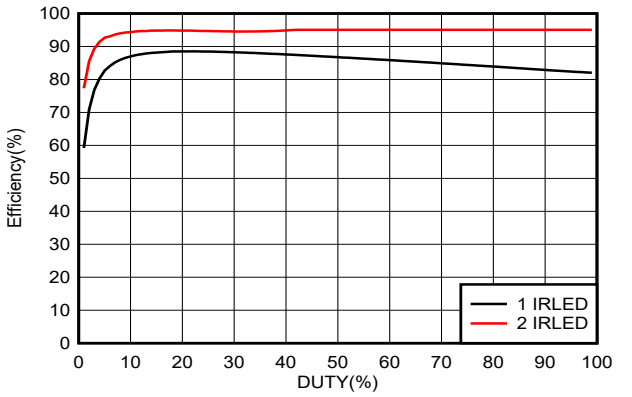

Iset = 1.5A L = 2.2µH 1 IRLED

**Figure 8-2. 1 IRLED Output Efficiency**



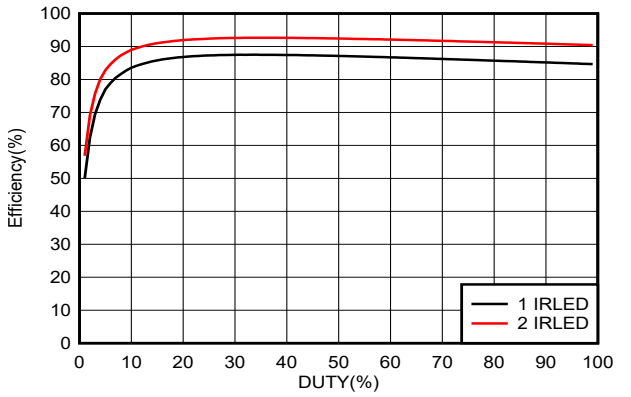

Iset = 1.5A L = 2.2µH 2 IRLED

**Figure 8-3. 2 IRLED Output Efficiency**



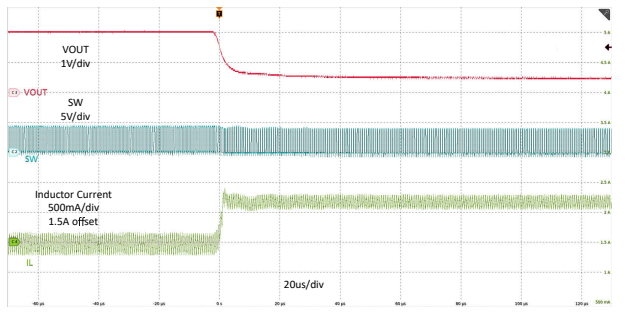

VIN = 3.6V Iset = 1.5A L = 2.2µH

**Figure 8-4. Output Efficiency at 3.6V Input Voltage**



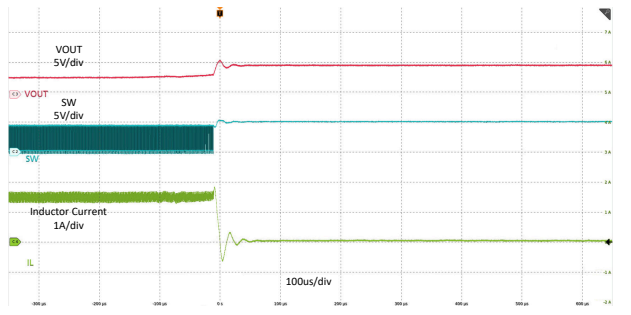

VIN = 5.5V Iset = 1.5A L = 2.2µH

**Figure 8-5. Output Efficiency at 5.5V Input Voltage**



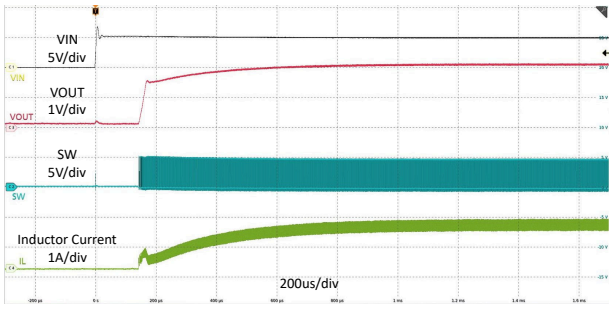

$V_{IN}$ = 5V Iset = 1.5A

**Figure 8-6. Vout short to GND protection**



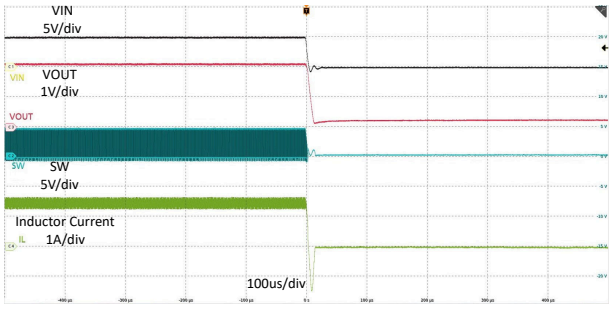

$V_{IN}$ = 5V Iset = 1.5A

**Figure 8-7. Vout Open Protection**



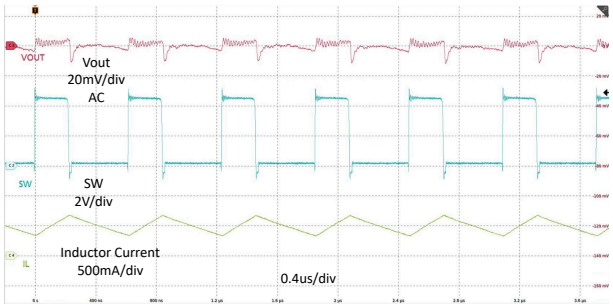

$V_{IN}$ = 5V Iset = 1.5A L = 2.2µH

**Figure 8-8. VIN Control Start Up with Load**



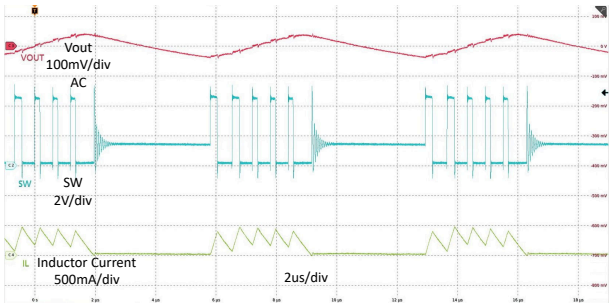

$V_{IN}$ = 5V Iset = 1.5A L = 2.2µH

**Figure 8-9. VIN Control Shutdown with Load**



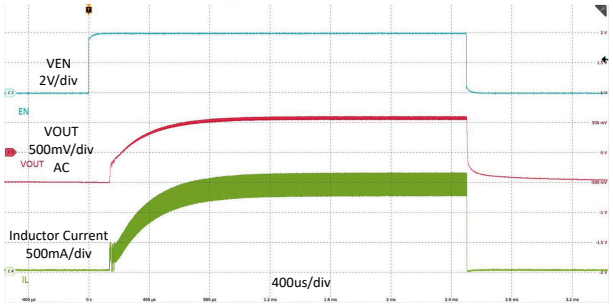

Vin = 5V $I_{OUT}$ = 0.5A

**Figure 8-10. PWM Operation**



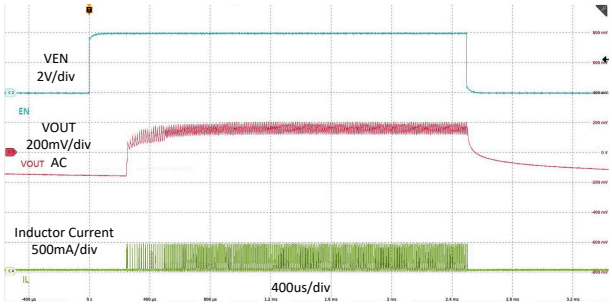

Vin = 5V $I_{OUT}$ = 0.1A

**Figure 8-11. Power Save Mode Operation**




$I_{OUT}$ = 1.5A L=2.2µH

**Figure 8-12. EN Control Startup with Load**




$I_{OUT}$ = 0.1A L=2.2µH

**Figure 8-13. EN Control Startup with Load**

## 8.3 Power Supply Recommendations

The power supply to the TPS92201 must have a current rating according to the supply voltage, output voltage and output current.

## 8.4 Layout

### *8.4.1 Layout Guidelines*

The PCB layout is an important step to maintain the high performance of the TPS92201 device.

- The input/output capacitors and the inductor should be placed as close as possible to the IC. This keeps the power traces short. Routing these power traces direct and wide results in low trace resistance and low parasitic inductance.
- The low side of the input and output capacitors must be connected properly to the power GND to avoid a GND potential shift.
- The sense traces connected to FB are signal traces. Special care should be taken to avoid noise being induced. Keep these traces away from SW nodes.
- GND layers might be used for shielding.

### *8.4.2 Layout Example*

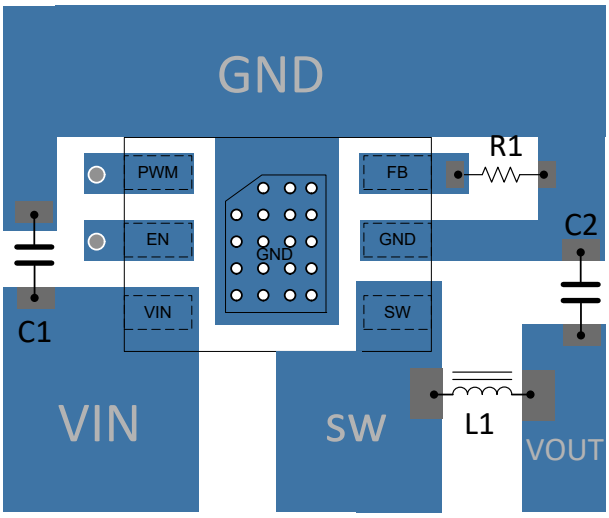



**Figure 8-14. TPS92201WSON Layout**

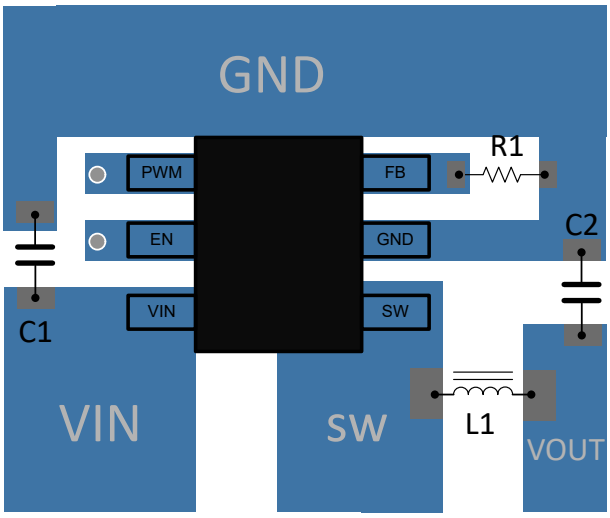



**Figure 8-15. TPS92201SOT Layout**

### *8.4.3 Thermal Considerations*

Implementation of integrated circuits in low-profile and fine-pitch surface-mount packages typically requires special attention to power dissipation. Many system-dependent issues such as thermal coupling, airflow, convection surfaces, and the presence of other heat-generating components affect the power dissipation limits of a given component.

Two basic approaches for enhancing thermal performance are listed below:

- Improving the power dissipation capability of the PCB design
- Introducing airflow in the system

For more details on how to use the thermal parameters, see the application notes: Thermal Characteristics Application Notes SZZA017 and SPRA953.

# 9 Device and Documentation Support

## 9.1 Device Support

### *9.1.1 Custom Design With WEBENCH® Tools*

Click here to create a custom design using the TPS92201 device with the WEBENCH® Power Designer.

1. Start by entering the input voltage ($V_{IN}$), output voltage ($V_{OUT}$), and output current ($I_{OUT}$) requirements.
2. Optimize the design for key parameters such as efficiency, footprint, and cost using the optimizer dial.
3. Compare the generated design with other possible solutions from Texas Instruments.

The WEBENCH Power Designer provides a customized schematic along with a list of materials with real-time pricing and component availability.

In most cases, these actions are available:

- Run electrical simulations to see important waveforms and circuit performance
- Run thermal simulations to understand board thermal performance
- Export customized schematic and layout into popular CAD formats
- Print PDF reports for the design, and share the design with colleagues

Get more information about WEBENCH tools at www.ti.com/WEBENCH.

## 9.2 Documentation Support

### *9.2.1 Related Documentation*

*Semiconductor and IC Package Thermal Metrics Application Report* (SPRA953)

*Thermal Characteristics of Linear and Logic Packages Using JEDEC PCB Designs Application Report* (SZZA017)

## 9.3 Receiving Notification of Documentation Updates

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

## 9.4 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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## 9.5 Trademarks

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All trademarks are the property of their respective owners.

## 9.6 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.

## 9.7 Glossary

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

## 10 Revision History

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

| Changes from Revision A (August 2024) to Revision B (August 2024) | Page |
|---|---|
| • Updated docuent to include the SOT563-6 package option | 1 |

| Changes from Revision * (November 2023) to Revision A (August 2024) | Page |
|---|---|
| • Updated the ORDERABLE PART NUMBER's marketing status of from Product Preview to Production Data | 1 |
| • Updated Device Comparison table to include the DRL package | 2 |

## 11 Mechanical, Packaging, and Orderable Information

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

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TPS92201ADRLR | ACTIVE | SOT-5X3 | DRL | 6 | 4000 | RoHS & Green | SN | Level-1-260C-UNLIM | -40 to 85 | 3GDH | Samples |
| TPS92201ADRVR | ACTIVE | WSON | DRV | 6 | 3000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 34MH | Samples |
| TPS92201AMDRVR | ACTIVE | WSON | DRV | 6 | 3000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -55 to 125 | 3CZH | Samples |
| TPS92201DRVR | ACTIVE | WSON | DRV | 6 | 3000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 34LH | Samples |
| TPS92201MDRVR | ACTIVE | WSON | DRV | 6 | 3000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -55 to 125 | 3CXH | Samples |

(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.

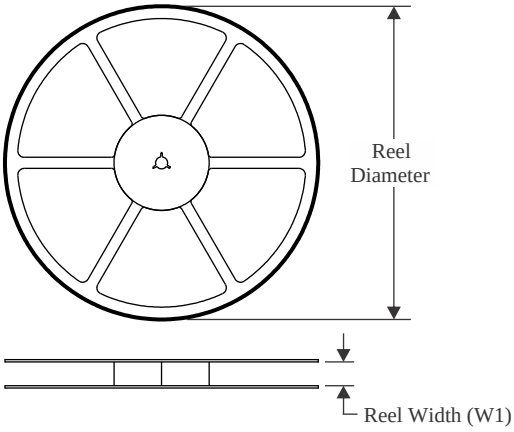
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

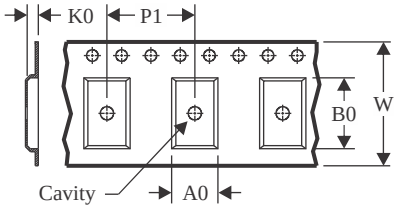
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

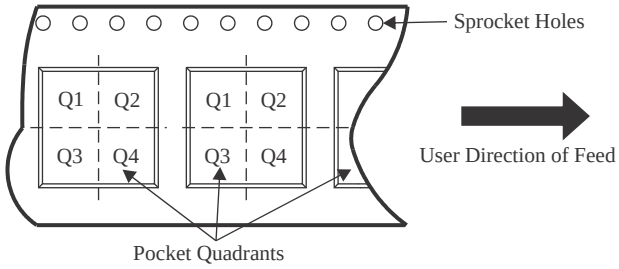



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

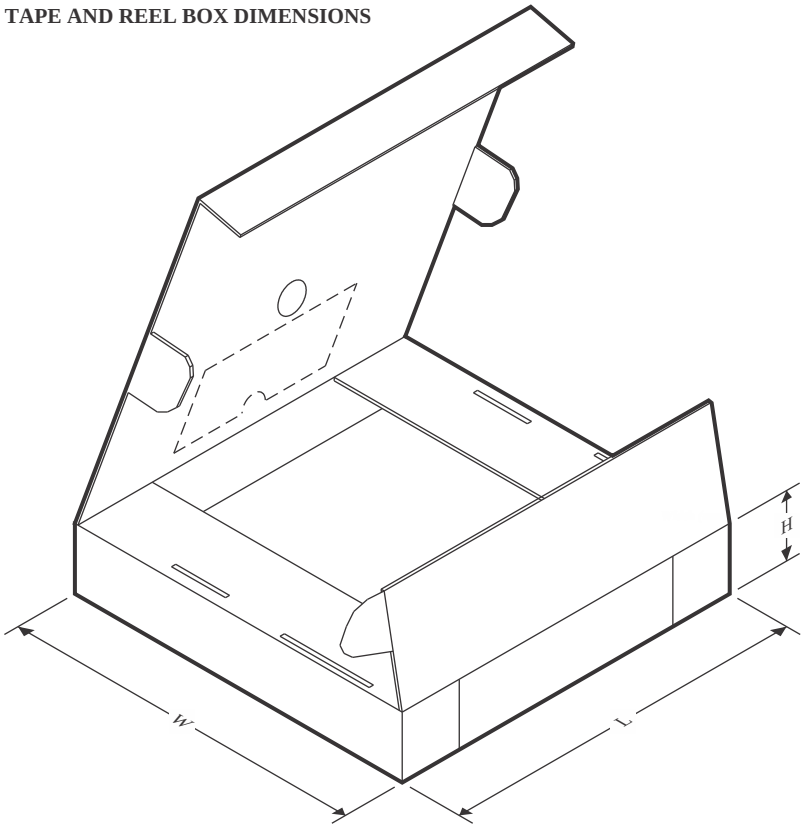
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TPS92201ADRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| TPS92201AMDRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| TPS92201DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| TPS92201MDRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |

TAPE AND REEL BOX DIMENSIONS

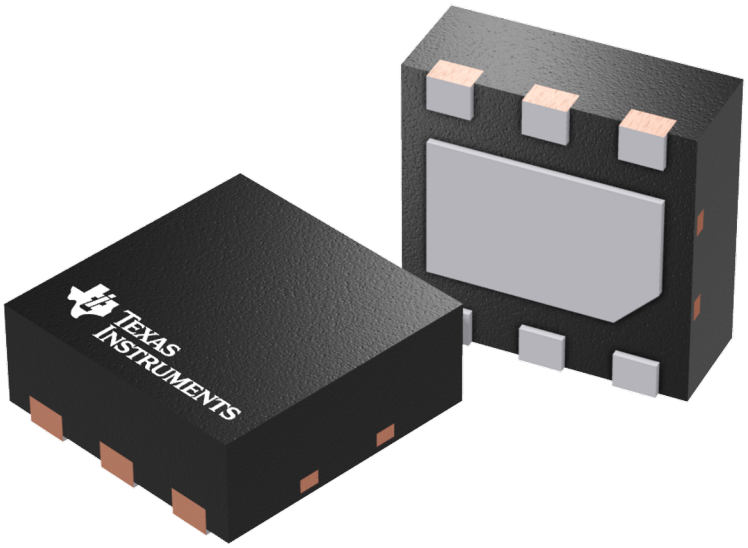



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TPS92201ADRVR | WSON | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| TPS92201AMDRVR | WSON | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| TPS92201DRVR | WSON | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| TPS92201MDRVR | WSON | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |

# DRV 6 WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



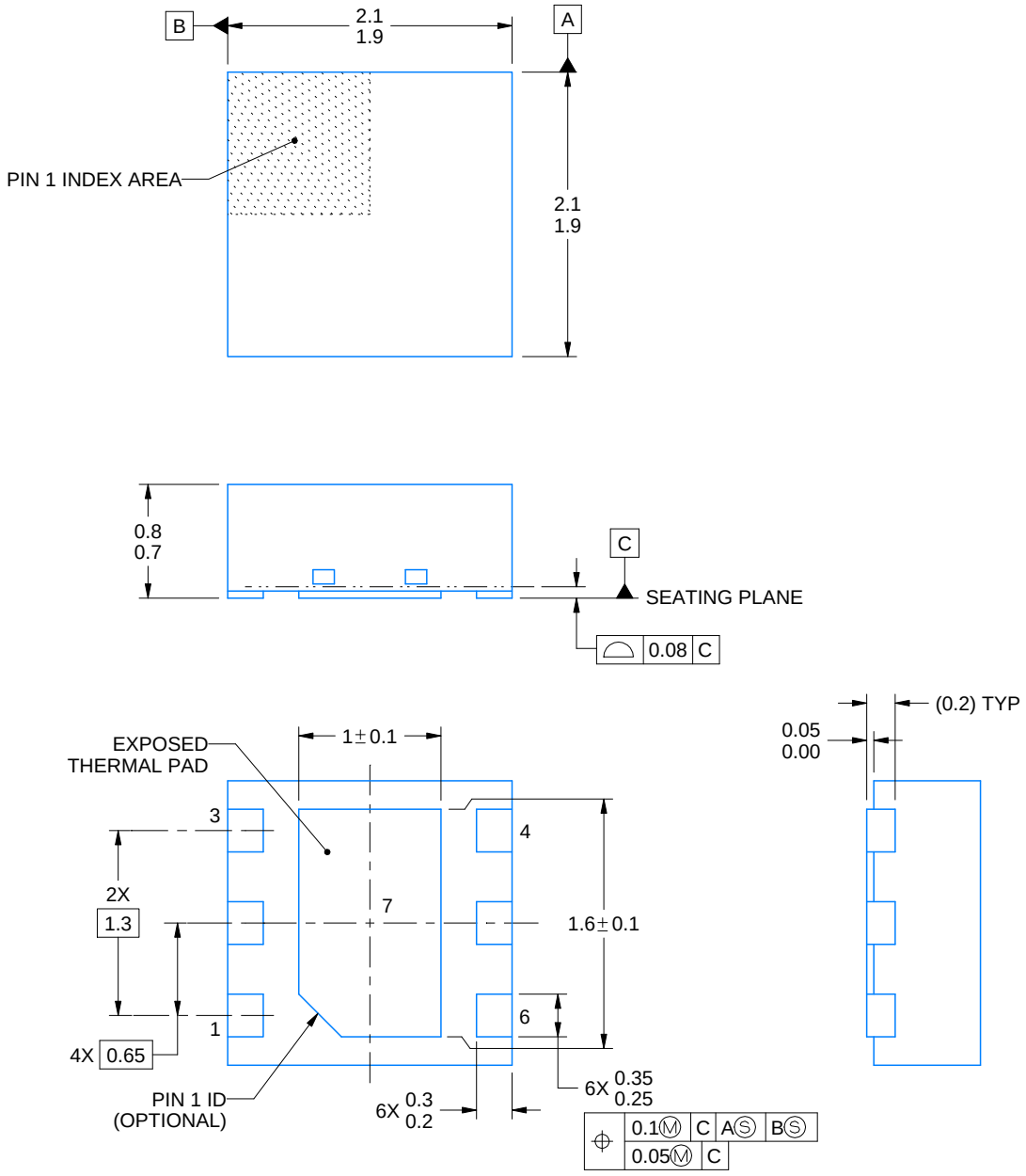

Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

# PACKAGE OUTLINE

## DRV0006A

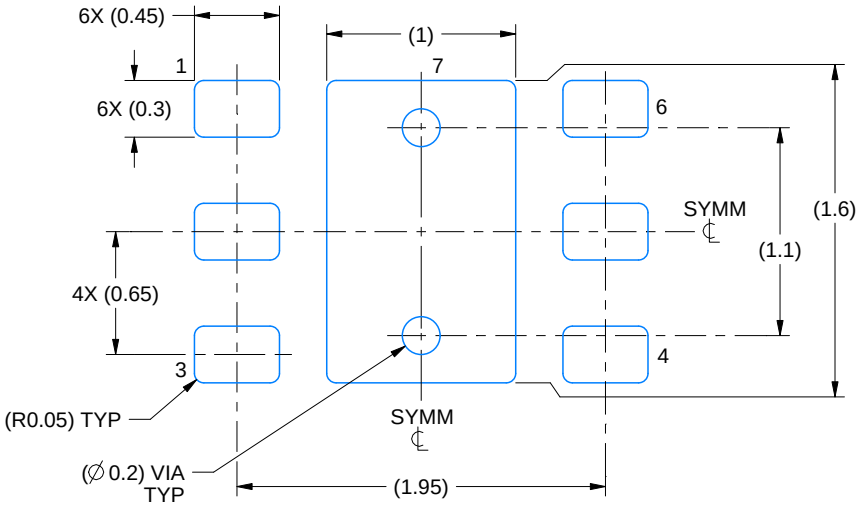
## WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD

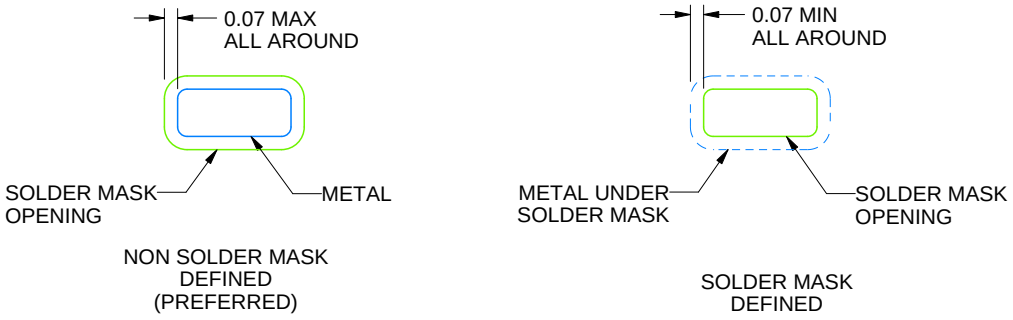



NOTES:

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 thermal and mechanical performance.




LAND PATTERN EXAMPLE
SCALE:25X




SOLDER MASK DETAILS

4222173/B 04/2018

NOTES: (continued)

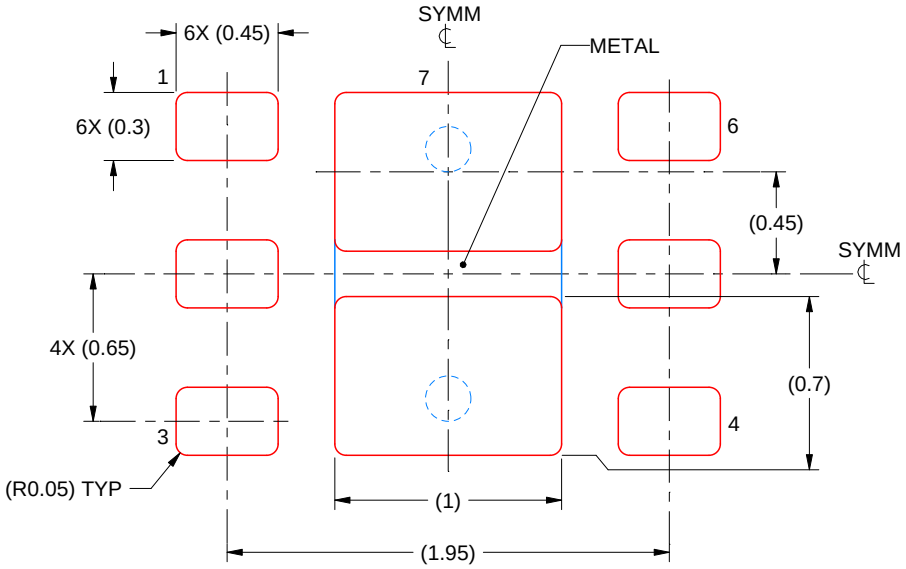
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If some or all are implemented, recommended via locations are shown.

# EXAMPLE STENCIL DESIGN

## DRV0006A

## WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD #7
88% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:30X

4222173/B 04/2018

NOTES: (continued)

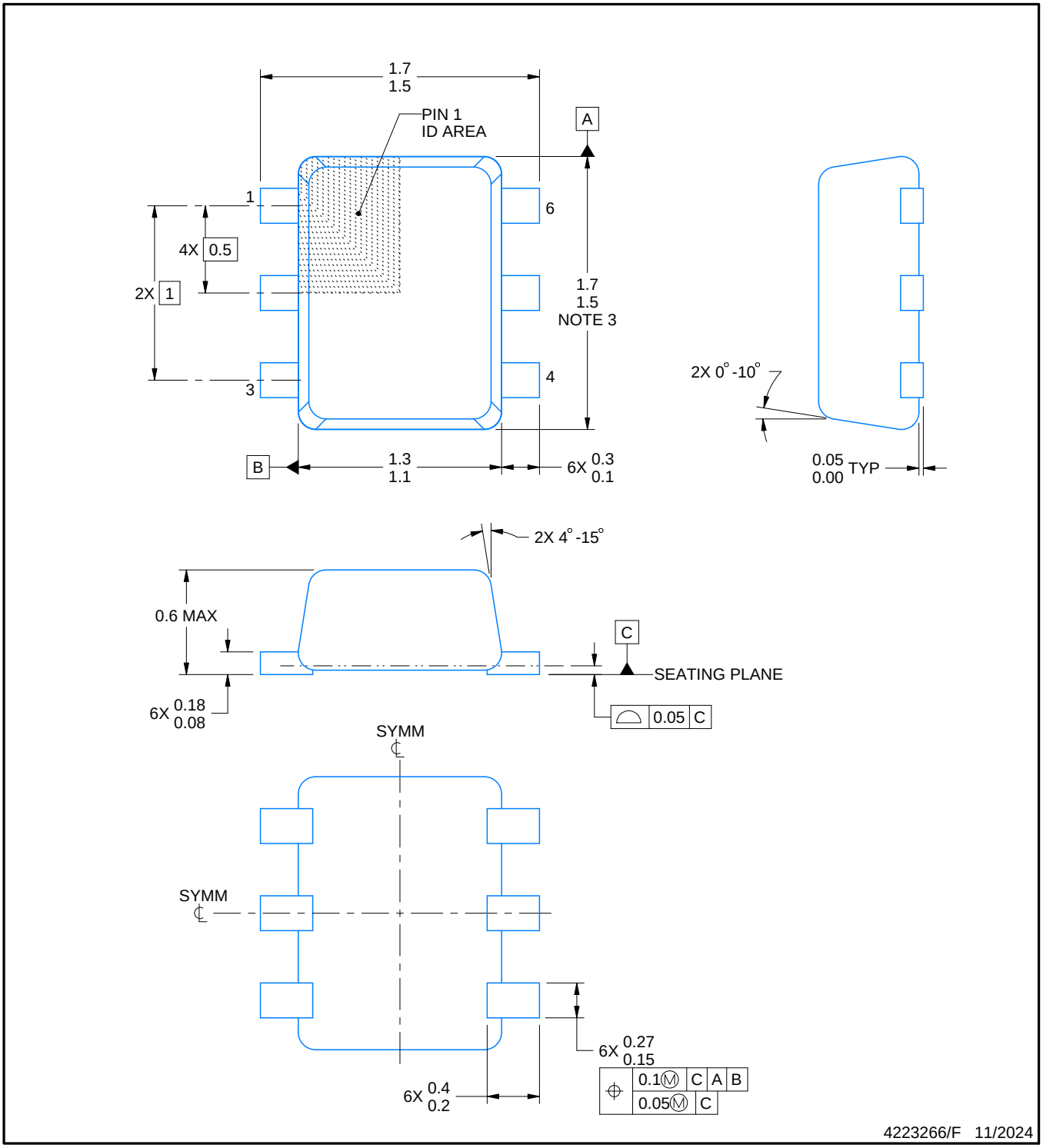
6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

# PACKAGE OUTLINE

## DRL0006A

## SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE




NOTES:

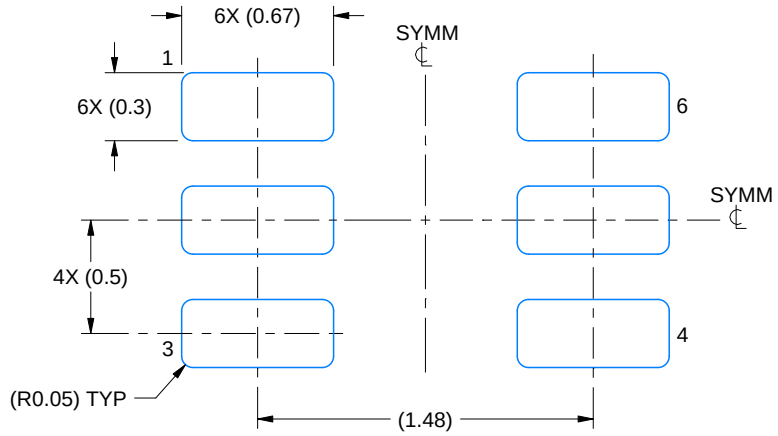
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-293 Variation UAAD

# EXAMPLE BOARD LAYOUT

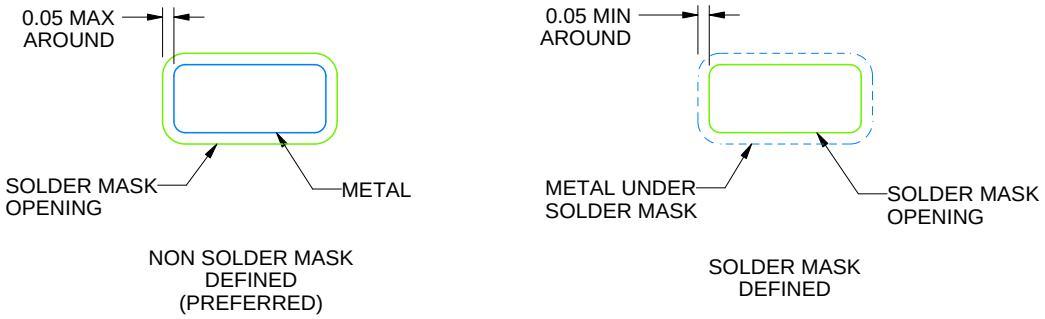
## DRL0006A

## SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE




LAND PATTERN EXAMPLE
SCALE:30X




SOLDERMASK DETAILS

4223266/F 11/2024

NOTES: (continued)

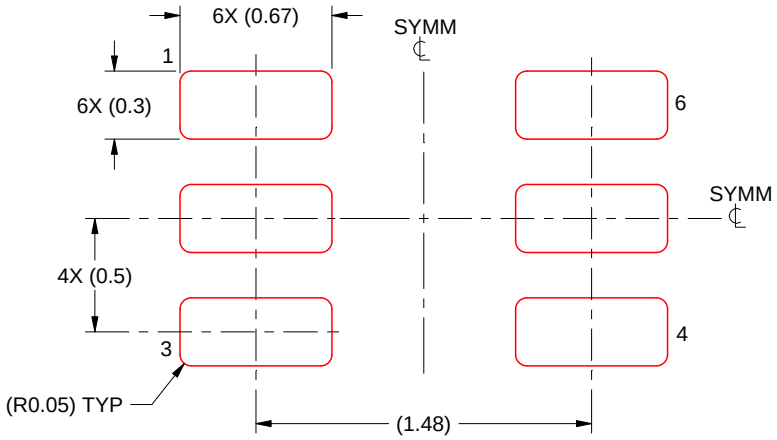
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
7. Land pattern design aligns to IPC-610, Bottom Termination Component (BTC) solder joint inspection criteria.

# EXAMPLE STENCIL DESIGN

## DRL0006A

## SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE




SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE:30X

4223266/F 11/2024

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

# IMPORTANT NOTICE AND DISCLAIMER

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