# High PSRR, 600mA LDO Regulator

## FEATURES

- Wide Input Voltage Range, 2.2V to 6.0V
- Adjustable Output Voltage
- Fast Transient Response
- Typical 420mV Dropout Voltage at 600mA Output Current
- Small Output Capacitor, 1uF
- Typical 65uA Quiescent Current
- Less Than 1uA Shutdown Current
- Dedicated Chip Enable Pin
- Soft Start 100us
- Over Current Limitation
- Thermal Protection
- RoHS Compliant and Halogen Free

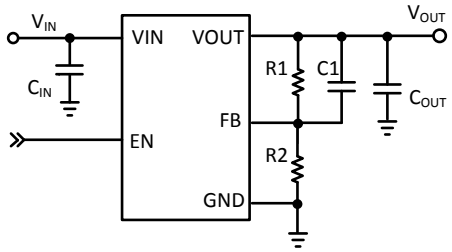
## APPLICATIONS

- Battery-Powered Equipment's
- Hand-Held Electrical Appliances
- Portable Communication Equipment's

## ORDERING INFORMATION

| PART | PACKAGE | RoHS | Ship, Quantity |
|---|---|---|---|
| ZTP7001 | TSOT-23-5L | Yes | Tape and Reel |

## Typical Application Circuits




ZTP7001

## DESCRIPTION

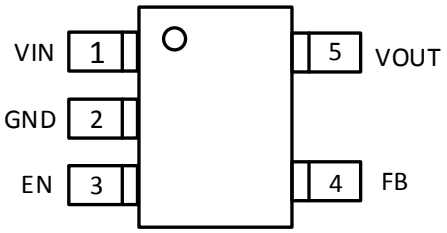
The ZTP7001 is a high performance LDO regulator specifically designed to deliver adjustable output voltage with high PSRR and fast transient response. Internal 700mohm PMOS pass transistor yields typical 420mV dropout voltage at 600mA output current.

Typical quiescent current is only 65uA. A logic low on the enable input, EN, shuts down the output and reduces the supply current to less than 1uA. The ZTP7001 works stably with as low as 1uF ceramic output capacitor, minimizing board space requirement.

Other features include soft start, high output accuracy, output current limiting, and thermal protection. The ZTP7001 is available in the TSOT23-5 package.

## Pins Configuration

TSOT23-5




ZTP7001



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## Absolute Maximum Ratings

Input Supply Voltage $V_{IN}$ ..... –0.3V to +6.5V
Voltage at EN ..... –0.3V to +6.5V
Others ..... –0.3V to ($V_{IN}$ + 0.3V)
Maximum Power Dissipation $P_D$@$T_A$ = 25°C ..... 0.4W
ESD (Human Body Mode) ..... 2kV
ESD (Machine Mode) ..... 200V

**CAUTION**: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

## Package Thermal Characteristics

Thermal Resistance, $\theta_{JA}$ ..... 250°C /W
Thermal Resistance, $\theta_{JC}$ ..... 25°C/W

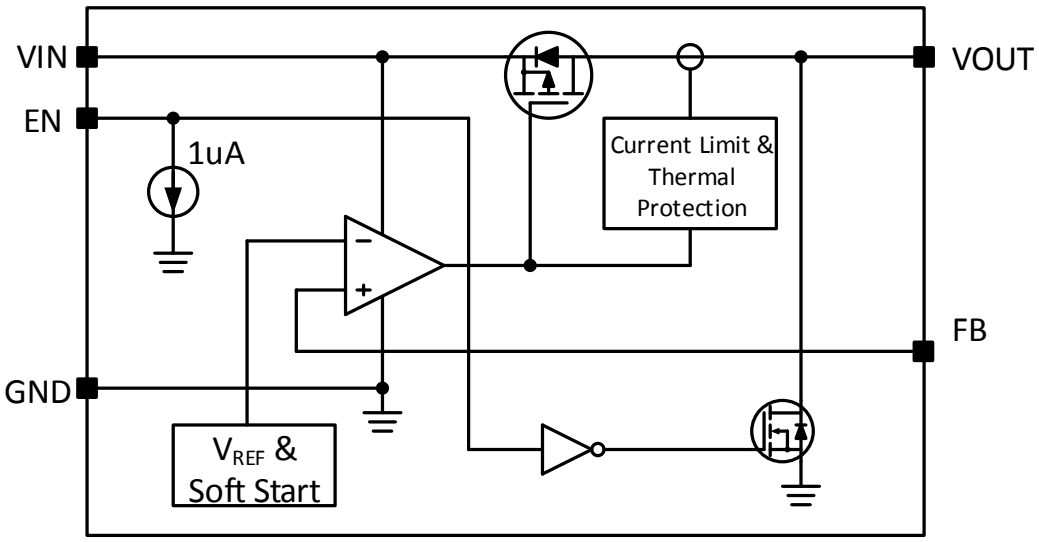
## Electro-Static Discharge Sensitivity

This integrated circuit can be damaged by ESD. It is recommended that all integrated circuits be handled with proper precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure.

## Pins Description

| Pin | Symbol | Description |
|---|---|---|
| 1 | VIN | Input Voltage. |
| 2 | GND | Ground. |
| 3 | EN | Active High Chip Enable. |
| 4 | FB | Output Voltage Feedback. |
| 5 | VOUT | Output Voltage. |

## Functional Block Diagram



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## Recommended Operation Conditions

| PARAMETER | MIN | TYP | Max | Unit |
|---|---|---|---|---|
| Continuous Junction Temperature | –40 | -- | 125 | °C |
| Ambient Temperature Range | –40 | -- | 85 | °C |
| Input Voltage Range | 2.2 | -- | 6.0 | V |

## Electrical Specifications

$V_{IN}$ = $V_{EN}$ = 3.3V and $T_A$ = 25°C unless otherwise specified

| PARAMETER | Symbol | TEST CONDITIONS | MIN | TYP | Max | Unit |
|---|---|---|---|---|---|---|
| Input Supply Voltage | $V_{IN}$ | | 2.2 | -- | 6.0 | V |
| VIN Under Voltage Lockout | $V_{UVLO}$ | | -- | 2 | 2.1 | V |
| Shutdown Current | $I_{SD}$ | $V_{EN}$ = 0V | -- | -- | 1 | uA |
| Quiescent Current | $I_Q$ | $I_{OUT}$ = 0mA | -- | 65 | -- | uA |
| FB Pin Voltage | $V_{FB}$ | $I_{OUT}$ = 10mA | 792 | 800 | 808 | mV |
| Maximum Output Current | $I_{OUT}$ | | 600 | 800 | -- | mA |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | 1mA < $I_{OUT}$ < 600mA | -- | 30 | 50 | mV |
| On-Resistance of Pass Element | $R_{DS(ON)}$ | | -- | 700 | -- | mΩ |
| Dropout Voltage | $V_{DP}$ | $I_{OUT}$ = 600mA | -- | 420 | -- | mV |
| Line Regulation | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{OUT}$ + 0.42V < $V_{IN}$ < 6.0V | -- | 0.02 | -- | %/V |
| Output Noise | | BW = 10Hz to 100kHz, $I_{OUT}$ = 10mA | -- | 70 | -- | uVrms |
| Power Supply Ripple Rejection | PSRR | $I_{OUT}$ = 10mA, f = 1kHz | -- | -70 | -- | dB |
| | | $I_{OUT}$ = 10mA, f = 10kHz | -- | -60 | -- | dB |
| Short Circuit Limit | | $V_{OUT}$ = 0V | -- | 100 | -- | mA |
| EN Pull-Down Constant Current | $I_{EN}$ | $V_{EN}$ = 3.3V | -- | 1 | -- | uA |
| EN Input High Threshold | $V_{IH}$ | | 1.6 | -- | -- | V |
| EN Input Low Threshold | $V_{IL}$ | | -- | -- | 0.4 | V |
| Soft Start Time | $t_{SS}$ | | -- | 100 | -- | uS |
| Thermal Shutdown Temperature | $T_{SD}$ | | -- | 160 | -- | °C |
| Thermal Shutdown Hysteresis | $\Delta T_{SD}$ | | -- | 30 | -- | °C |



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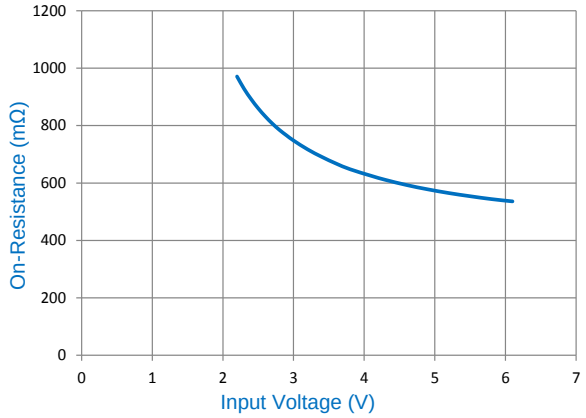
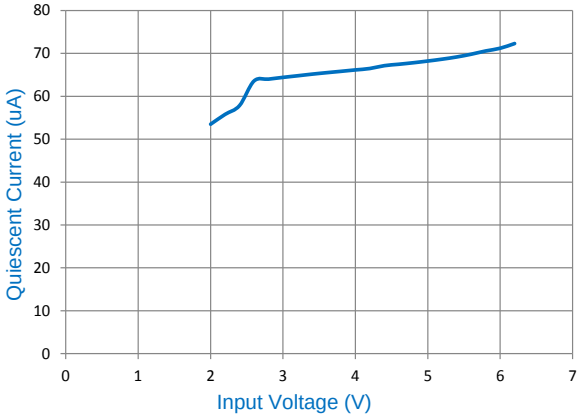
## Typical Characteristics

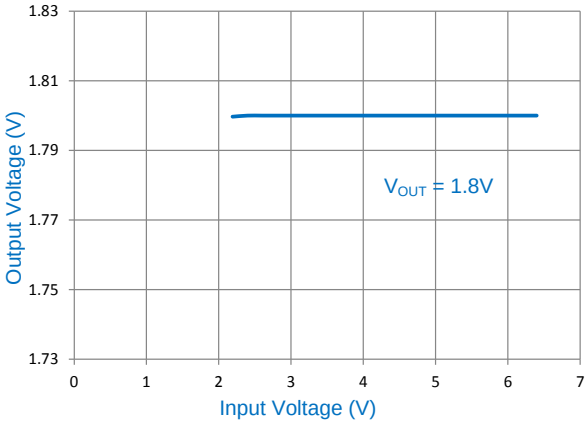
### On-Resistance vs. Input Voltage



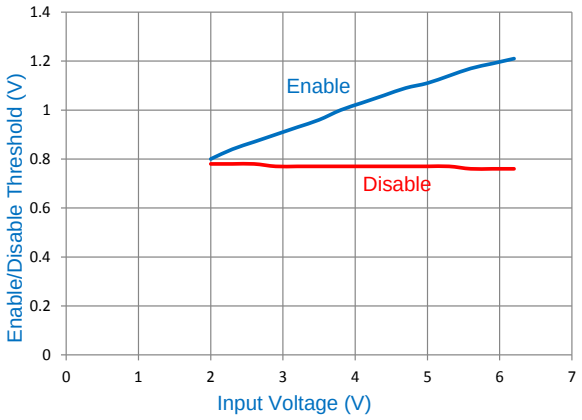

### Quiescent Current vs. Input Voltage



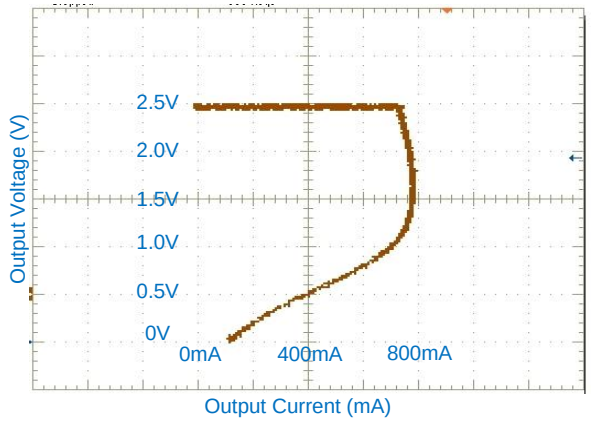

### Line Regulation



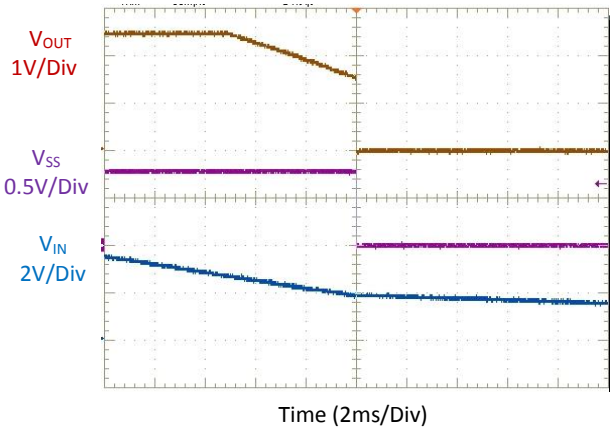

### Enable Disable Threshold vs. Input Voltage




### Output Current Limit




### Power Off Waveforms



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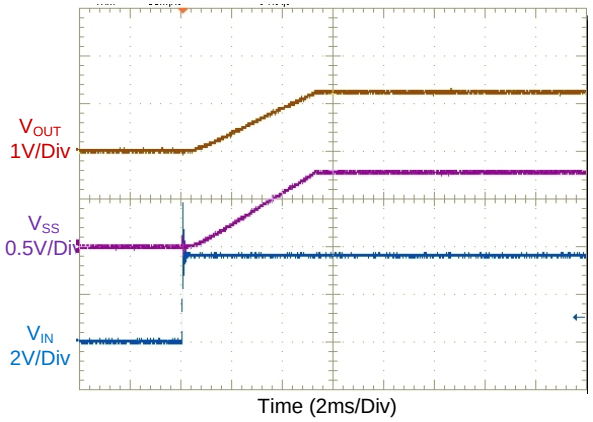
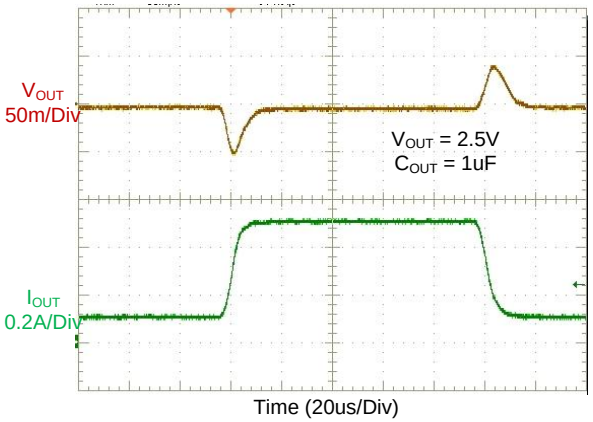
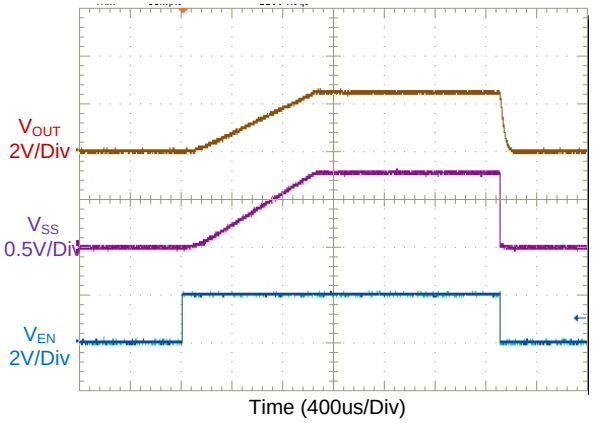


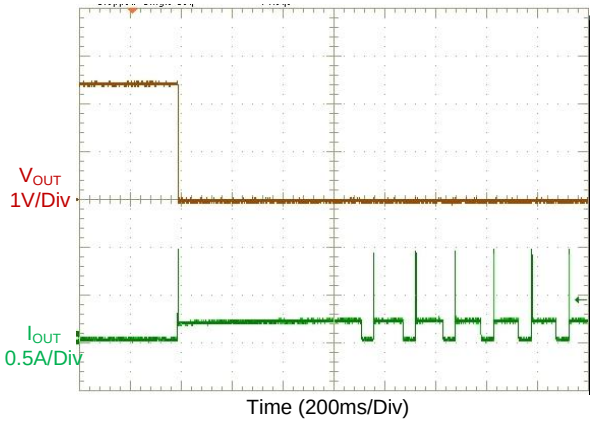

## Load Transient Response



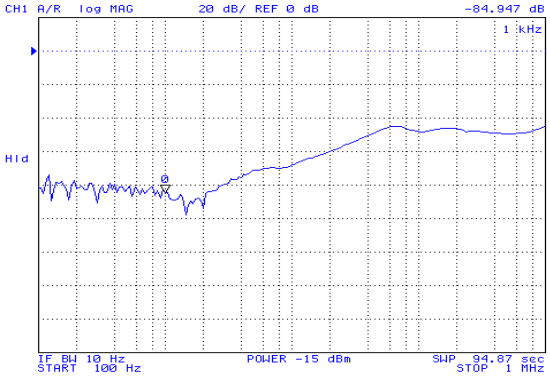

## Turn On/Off Waveforms




## Output Short Circuit Response

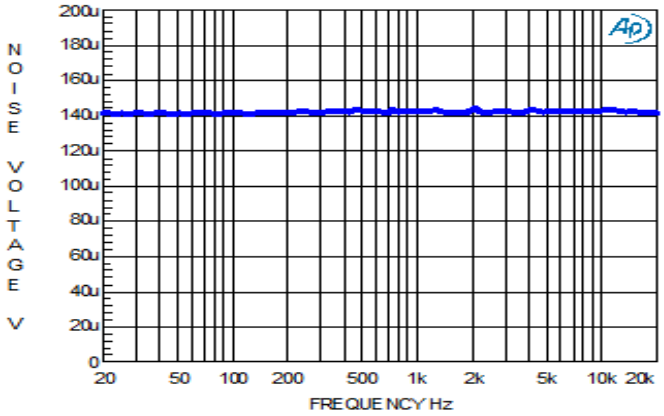



## PSRR




$V_{IN}$ = 3.3V, $V_{OUT}$ = 1.6V, $I_{OUT}$ = 100mA

## Noise Level




$V_{IN}$ = 3.3V, $V_{OUT}$ = 1.6V, $I_{OUT}$ = 100mA

ZTP7001



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## Functional Pin Description

**VIN:** Input Voltage. Connect a minimum 1uF ceramic capacitor to this pin for stable operation.

**GND:** Ground.

**EN:** Active High Chip Enable. This pin is internally pulled down by a 1uA current source.

**FB:** Output Voltage Feedback. The FB voltage is regulated to 0.8V. Connect a resistive voltage divider to set the output voltage.

**VOUT:** Output Voltage. Connect a minimum 1uF ceramic capacitor to this pin for stable operation.

## OPERATION PRINCIPLES

The ZTP7001 low dropout regulator (LDO) operates with a very low input voltage (>2.2V). The ZTP7001 can operate at low input voltage due to low voltage circuit design techniques and a PMOS pass element that exhibits low dropout. The dropout voltage is typically 420mV at 600mA output current.

### Chip Enable

Typical quiescent current is only 65uA. A logic low on the enable input, EN, shuts down the output and reduces the supply current to less than 1uA. The EN pin is internally pulled down by a 1uA current source and may be tied to VIN in applications where the shutdown feature is not used.

### Output Discharging Resistor

An internal 100Ω MOSFET is connected to VOUT pin and discharges the output voltage to ground when the chip is disabled or thermal protection is triggered.

### Soft Start

The ZTP7001 features soft start and the soft start time is fixed as 100us.

### Output Voltage Programming

The output voltage of the ZTP7001 adjustable regulator is programmed using an external resistive divider as shown in the typical application circuit. The output voltage is calculated as:

$$V_{OUT} = V_{REF} \times \frac{R1 + R2}{R2}$$

Where $V_{REF}$ = 0.8V typ (the internal reference voltage.)

Resistors R1 and R2 should be chosen for approximately 10uA divider current. Lower value resistors can be used but offer no inherent advantage and waste more power. Higher values should be avoided as leakage currents at FB increase the output voltage error.

### Current Limit and Thermal Protection

Current limiting and thermal protection prevent damage by excessive output current and/or power dissipation. The device switches into a constant-current mode at approximately 800mA. Further load reduces the output voltage instead of increasing the output current. The thermal protection shuts the regulator off if the junction temperature rises above 160°C. Recovery is automatic when the junction temperature drops approximately 30°C below the high temperature trip point.

### Pass Element

The ZTP7001 integrates a 700mΩ PMOS pass element that enables very low dropout voltage. The PMOS pass element includes a back diode that safely conducts reverse current when the input voltage level drops below the output voltage level.

## Application Information

### Capacitors Selection

Select carefully the external capacitors carefully to ensure stability and performance. Place the externally capacitors close to the IC with a distance no longer than 0.5 inches.

The input capacitor $C_{IN}$ with larger value and lower ESR (equivalent series resistance) provides better PSRR and line-transient response.



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The ZTP7001 is specifically designed to work with low ESR ceramic output capacitor in space-saving and performance consideration. A 1uF ceramic capacitor is adequate for stable operation. However, for best load and line transient response, output capacitor larger than 4.7uF is recommended.

## Power Supply Rejection Ration (PSRR)

PSRR is a measure of how well a circuit rejects ripple coming from the input power supply at various frequencies and is very critical in many RF and wireless applications. PSRR is defined as the gain from the input ripple to output ripple over a wide frequency range (10Hz to 10MHz), Note that at heavy load measuring, $\Delta V_{IN}$ will cause temperature deviation. Temperature will cause $\Delta V_{OUT}$ voltage. So the heavy load PSRR measuring includes temperature effect.

## Thermal Consideration

The maximum power dissipation is specified as:

$$P_{D(MAX)} = \frac{(125°C - TA)}{\theta_{JA}}$$

where $T_{J(MAX)}$ is the maximum operation junction temperature, $T_A$ is the ambient temperature and $\theta_{JA}$ is the junction to ambient thermal resistance.

The ZTP7001 features thermal protection that shuts down the IC if the junction temperature is higher than 160°C. However, the power dissipation should be well designed to keep the continuous junction temperature below 125°C for maximum reliability.

$\theta_{JA}$ depends on the thermal resistance of the package, PCB layout, surrounding airflow. For SOT-23-5 package, the thermal resistance $\theta_{JA}$ is 250°C /W on the standard JEDEC 51-3 single layer thermal test board. The maximum power dissipation at TA = 25°C can be calculated as:

$$P_{D(MAX)} = \frac{(125°C - 25°C)}{250°C/W} = 0.4W$$

Because of the small size of the TSOT23-5 package, it is very important to use a good thermal PC board layout to maximize the allowable power dissipation. The thermal path for the heat generated by the IC is from the die to the copper lead frame, through the package (especially the ground lead), to the PCB board cooper. The PC board copper. The PCB board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Feed through via to inner or backside copper layer are also useful in improving the overall thermal performance of the LDO regulator. Other heat sources on the board, not related to the LDO regulator, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum allowable power dissipation. The following table lists thermal resistance for several different board sizes and copper areas. All measurements were taken in still air on 3/32" FR-4 board with the device mounted on topside.

Table 1. Measured Thermal Resistance (2-Layer Board)

| Copper Area(mm2) | | Board Area (mm2) | $\theta_{JA}$ (°C/W) |
|---|---|---|---|
| Top Side | Back Side | | |
| 2500 | 2500 | 2500, 2-Layer | 125 |
| 1000 | 2500 | 2500, 2-Layer | 125 |
| 225 | 2500 | 2500, 2-Layer | 130 |
| 100 | 2500 | 2500, 2-Layer | 135 |
| 50 | 2500 | 2500, 2-Layer | 150 |

## Layout Considerations

Careful PCB Layout is necessary for better performance. The following guidelines should be followed for good PCB layout.

- Place the input and output capacitors as close as possible to the IC.
- Keep $V_{IN}$ and $V_{OUT}$ trace as possible as short and wide.
- Use a large PCB ground plane for maximum thermal dissipation.



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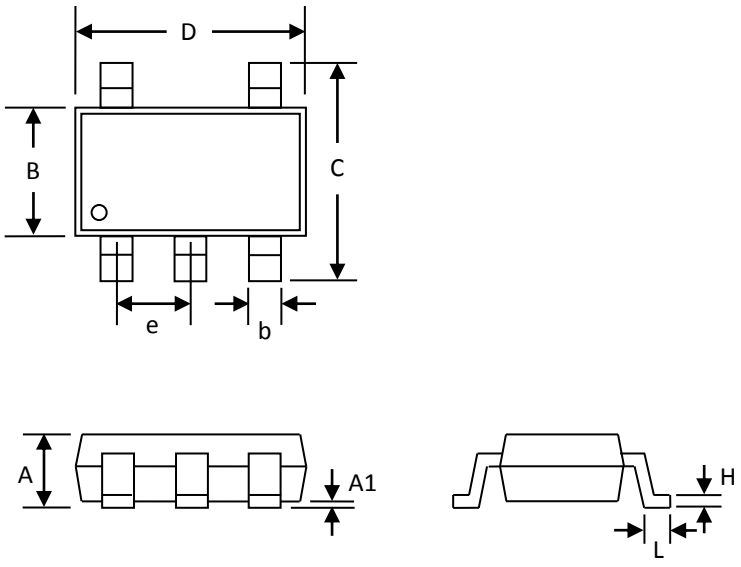
## PACKAGE DIMENSIONS TSOT23-5




| Symbol | Dimensions in mm | |
|---|---|---|
| | Min | Max |
| A | 0.700 | 0.900 |
| A1 | 0.000 | 0.130 |
| B | 1.500 | 1.700 |
| b | 0.300 | 0.559 |
| C | 2.500 | 3.100 |
| D | 2.800 | 3.100 |
| e | 0.950 BSC | |
| H | 0.080 | 0.200 |
| L | 0.200 | 0.800 |



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