# 5-V, 40-MHz, Zero-Crossover, Low Input Bias Current, RRIO Amplifier

## Features

- Supply Voltage: 2.2 V to 5.5 V
- Precision with Zero-crossover Distortion
- Low Offset Voltage: ±75 μV Maximum
- Low Offset Drift: 0.5 μV/℃
- Rail-to-Rail Input and Output
- Gain-Bandwidth Product: 40-MHz
- Unit Gain Stable
- Slew Rate: 30 V/μs
- Low Input Bias Current: ±1 pA Maximum
- 5-kV HBM, 1.5-kV CDM, 600-mA Latch up
- Operation Temperature Range: –40°C to 125°C

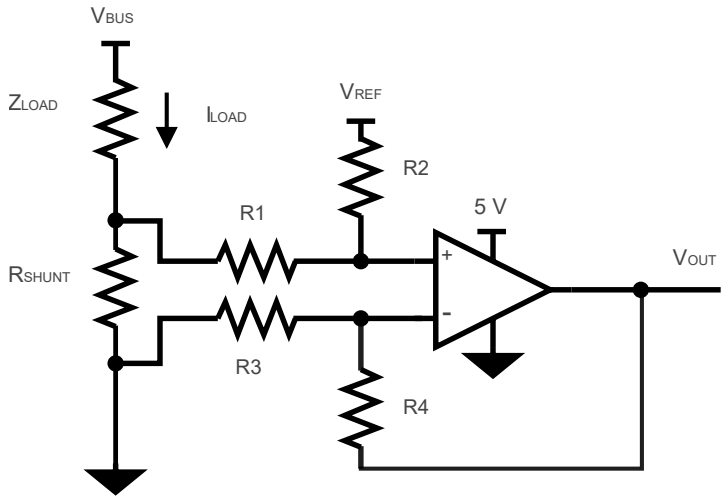
## Applications

- Optical module
- Sensor Interface
- Motor Control
- Industrial Control
- Audio

## Description

The TPA599x is a series of the newest amplifiers with ±75 μV low offset, low noise, low input bias current, and stable high-frequency response. The series incorporates proprietary and patented design techniques from the 3PEAK. The TPA599x aims to achieve excellent AC performance with 40-MHz bandwidth, 30-V/μs slew rate, and low distortion while drawing only 8-mA quiescent current per amplifier. The input common-mode voltage range extends to rail-to-rail, and the outputs swing rail-to-rail.

## Typical Application Circuit




$V_{OUT} = (I_{LOAD} \times R_{SHUNT}) \times (R2 / R1) + V_{REF}$

When R3 = R1, R2 = R4, $R_{SHUNT} << R1$

# Table of Contents

## Revision History

| Date | Revision | Notes |
|---|---|---|
| 2026-01-13 | Rev.A.0 | Initial release |

## Pin Configuration and Functions

TPA5991

SOT23-5 Package

Top View

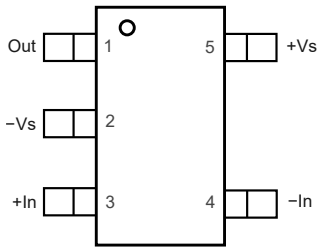



**Table 1. Pin Functions: TPA5991**

| Pin No. | Name | I/O | Description |
|---|---|---|---|
| 1 | Out | Output | Output |
| 2 | $-V_S$ | | Negative power supply |
| 3 | +In | Input | Noninverting input |
| 4 | −In | Input | Inverting input |
| 5 | $+V_S$ | | Positive power supply |

TPA5992
SOP8/MSOP8
Top View

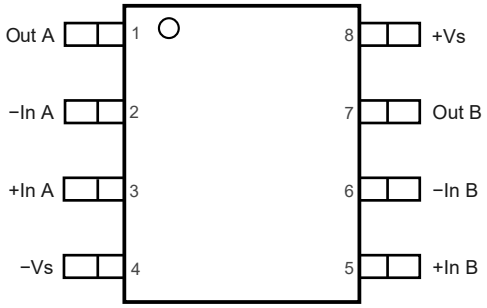



**Table 2. Pin Functions: TPA5992**

| Pin No. | Name | I/O | Description |
|---|---|---|---|
| 1 | Out A | O | Output |
| 2 | −In A | I | Inverting input |
| 3 | +In A | I | Non-inverting input |
| 4 | $-V_S$ | | Negative power supply |
| 5 | +In B | I | Non-inverting input |
| 6 | −In B | I | Inverting input |
| 7 | Out B | O | Output |
| 8 | $+V_S$ | | Positive power supply |

TPA5992
WLCSP
Top View

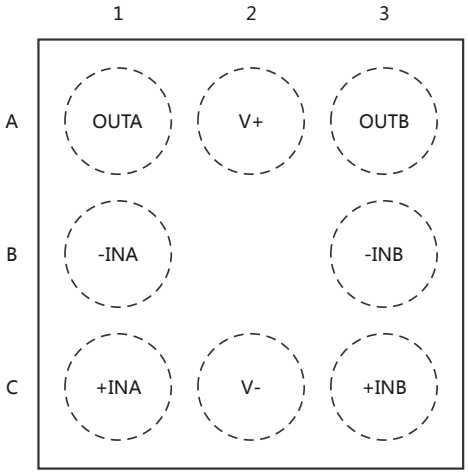



**Table 3. Pin Functions: TPA5992**

| Pin No. | Name | I/O | Description |
|---|---|---|---|
| 1 | Out A | O | Output |
| 2 | −In A | I | Inverting input |
| 3 | +In A | I | Non-inverting input |
| 4 | $-V_S$ | | Negative power supply |
| 5 | +In B | I | Non-inverting input |
| 6 | −In B | I | Inverting input |
| 7 | Out B | O | Output |
| 8 | $+V_S$ | | Positive power supply |

# Specifications

## Absolute Maximum Ratings (1)

Over operating ambient temperature (unless otherwise noted) (1)

| Parameter | | Min | Max | Unit |
|---|---|---|---|---|
| | Supply Voltage, $(+V_S) – (–V_S)$ | | 6.5 | V |
| | Input Voltage | $(-V_S) – 0.3$ | 6.5 | V |
| | Differential Input Voltage | $(-V_S) - (+V_S)$ | $(+V_S) - (-V_S)$ | V |
| | Input Current: +IN, –IN (2) | −10 | 10 | mA |
| | Output Voltage | $(-V_S) - 0.3$ | $(+V_S) + 0.3$ | V |
| | Output Short-Circuit Duration | | Infinite | |
| $T_J$ | Maximum Operating Junction Temperature | | 150 | °C |
| $T_A$ | Operating Temperature Range | −40 | 125 | °C |
| $T_{STG}$ | Storage Temperature Range | −65 | 150 | °C |
| $T_L$ | 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.
(2) A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

## ESD, Electrostatic Discharge Protection

| Symbol | Parameter | Condition | Minimum Level | Unit |
|---|---|---|---|---|
| HBM | Human Body Model ESD | ANSI/ESDA/JEDEC JS-001 (1) | 5 | kV |
| CDM | Charged Device Model ESD | ANSI/ESDA/JEDEC JS-002 (2) | 1.5 | kV |
| LU | Latch Up | JESD 78, 25°C | 600 | mA |
| | | JESD 78, 125°C | 400 | mA |

(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 |
|---|---|---|---|---|---|
| $V_S$ | Supply Voltage, $(+V_S) - (-V_S)$ | 2.2 | | 5.5 | V |
| $T_A$ | Operating Temperature Range | −40 | | 125 | °C |

## Thermal Information

| Package Type | $\theta_{JA}$ | $\theta_{JC}$ | Unit |
|---|---|---|---|
| SOT23-5 | 250 | 81 | °C/W |
| SOP8 | 158 | 43 | °C/W |
| MSOP8 | 210 | 45 | °C/W |
| WLCSP | | | °C/W |

## Electrical Characteristics

All test conditions: $V_S$ = 5 V, $T_A$ = 25°C, $R_L$ = 10 kΩ, unless otherwise noted.

| Parameter | | Conditions | $T_A$ | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Power Supply** | | | | | | | |
| $V_S$ | Supply Voltage Range | | | 2.2 | | 5.5 | V |
| $I_Q$ | Quiescent Current per Amplifier | $V_S$ = 5 V | | | 4.5 | 8 | mA |
| | | $V_S$ = 5 V | -40°C to 125°C | | | 9 | mA |
| PSRR | Power Supply Rejection Ratio | $V_S$ = 2.2 V to 5.5 V | | 89 | 110 | | dB |
| | | $V_S$ = 2.2 V to 5.5V | -40°C to 125°C | 86 | | | dB |
| **Input Characteristics** | | | | | | | |
| $V_{OS}$ | Input Offset Voltage | $V_S$ = 5 V, $V_{CM}$ = 0 V | | −75 | ±20 | 75 | μV |
| $V_{OS}$ | Input Offset Voltage | $V_S$ = 5 V, $V_{CM}$ = 0 V | −40°C to 125°C | −160 | | 160 | μV |
| $V_{OS}$ | Input Offset Voltage | $V_S$ = 5 V, $V_{CM}$ = 0 V to 5V | | −100 | ±20 | 100 | μV |
| $V_{OS}$ | Input Offset Voltage | $V_S$ = 5 V, $V_{CM}$ = 0 V to 5V | −40°C to 125°C | −230 | | 230 | μV |
| $V_{OS}$ TC | Input Offset Voltage Drift | | −40°C to 125°C | | 0.5 | 1 | μV/°C |
| $I_B$(1) | Input Bias Current | $V_S$ = 5 V, $V_{CM}$ = 0 V to 5V | | −1 | 0.3 | 1 | pA |
| $I_B$(1) | Input Bias Current | $V_S$ = 5 V, $V_{CM}$ = 0 V to 5V | −40°C to 125°C | −100 | | 100 | pA |
| $I_{OS}$(1) | Input Offset Current | $V_S$ = 5 V, $V_{CM}$ = 0 V to 5V | | −1 | 0.1 | 1 | pA |
| $I_{OS}$(1) | Input Offset Current | $V_S$ = 5 V, $V_{CM}$ = 0 V to 5V | −40°C to 125°C | −100 | | 100 | pA |
| $C_{IN}$ | Input Capacitance | Differential Mode | | | 4 | | pF |
| $C_{IN}$ | Input Capacitance | Common Mode | | | 2 | | pF |
| Av | Open-loop Voltage Gain | | | 85 | 120 | | dB |
| CMRR | Common Mode Rejection Ratio | $V_S$ = 5 V, $V_{CM}$ = 0 V to 5V | | 96 | 125 | | dB |
| CMRR | Common Mode Rejection Ratio | $V_S$ = 5 V, $V_{CM}$ = 0 V to 5V | −40°C to 125°C | 90 | | | dB |
| CMRR | Common Mode Rejection Ratio | $V_S$ = 5 V, $V_{CM}$ = -0.1 V to 5.1V | | 90 | 120 | | dB |
| CMRR | Common Mode Rejection Ratio | $V_S$ = 5 V, $V_{CM}$ = -0.1 V to 5.1V | −40°C to 125°C | 80 | | | dB |
| $V_{CMR}$ | Common-mode Input Voltage Range | | | (V−) − 0.1 | | (V+) +0.1 | V |

| Parameter | | Conditions | $T_A$ | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Output Characteristics** | | | | | | | |
| | Output Swing from Positive Rail | $R_{LOAD}$ = 10 kΩ to $V_S$/2 | | | 3 | 10 | mV |
| | | | −40°C to 125°C | | | 15 | mV |
| | | $R_{LOAD}$ = 2 kΩ to $V_S$/2 | | | 10 | 25 | mV |
| | | | −40°C to 125°C | | | 30 | mV |
| | Output Swing from Negative Rail | $R_{LOAD}$ = 10 kΩ to $V_S$/2 | | | 2 | 10 | mV |
| | | | −40°C to 125°C | | | 15 | mV |
| | | $R_{LOAD}$ = 2 kΩ to $V_S$/2 | | | 10 | 25 | mV |
| | | | −40°C to 125°C | | | 30 | mV |
| $I_{SC}$ | Output Short-Circuit Current | Source | | | 80 | | mA |
| | | Sink | | | 80 | | mA |
| | Capacitive Load Drive | | | | 50 | | pF |
| **AC Specifications** | | | | | | | |
| GBW | Gain-Bandwidth Product | G=10 | | | 40 | | MHz |
| SR | Slew Rate | G = 1, 1 V step | | | 30 | | V/μs |
| PM | Phase Margin | | | | 50 | | ° |
| GM | Gain Margin | | | | 11 | | dB |
| **Noise Performance** | | | | | | | |
| $E_N$ | Input Voltage Noise | f = 0.1 Hz to 10 Hz | | | 6 | | $\mu V_{PP}$ |
| $e_N$ | Input Voltage Noise Density | f = 1 kHz | | | 18 | | nV/√Hz |
| | | f = 10 kHz | | | 6.7 | | nV/√Hz |
| | | f = 100 kHz | | | 6 | | nV/√Hz |
| $i_N$ | Input Current Noise | f=10 kHz | | | 5 | | fA/√Hz |
| THD+N | Total Harmonic Distortion and Noise | f = 1 kHz, G =1, $R_L$ = 10 kΩ, $V_{OUT}$ = 4 $V_{pp}$ | | | 0.0003 | | % |

(1) Guaranteed by design.

## Typical Performance Characteristics

All test conditions: $V_S$ = ±5 V, $V_{CM}$ = 0 V, $R_L$ = 10 kΩ, unless otherwise noted.

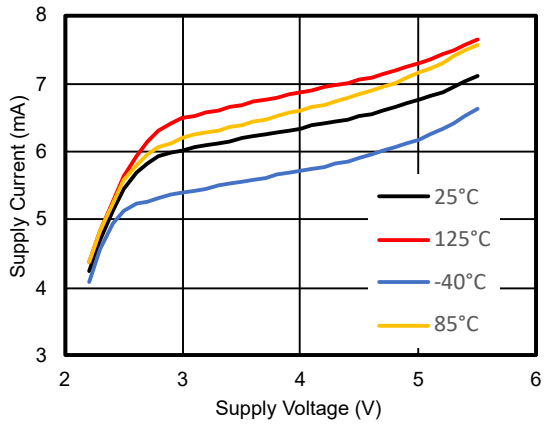



**Figure 1. Quiescent Current vs. Supply Voltage**

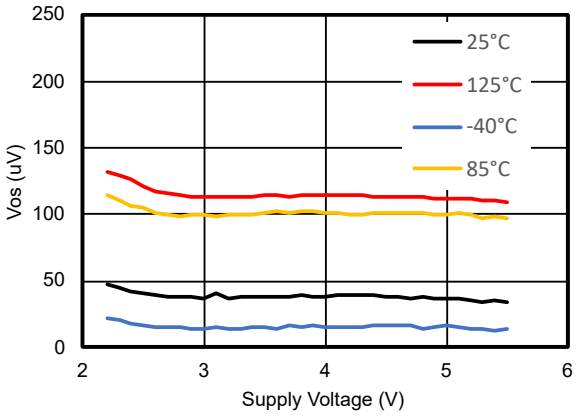



**Figure 2. Offset Voltage vs. Supply Voltage**

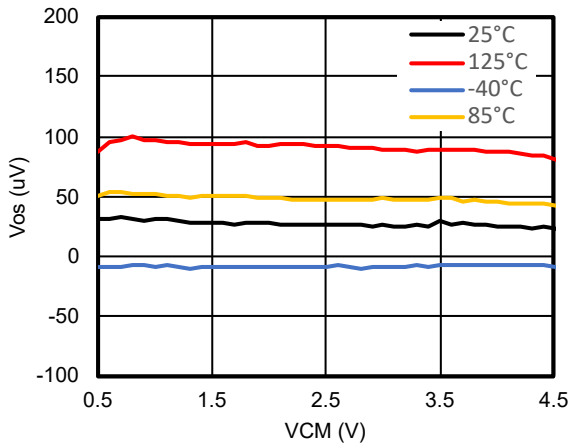



**Figure 3. Offset Voltage vs. Common-Mode Voltage**

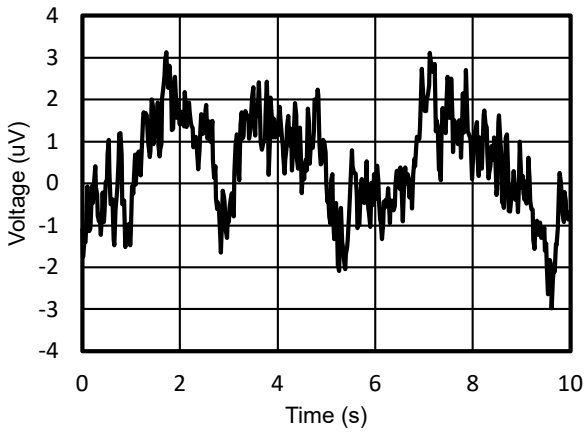



**Figure 4. 0.1-Hz to 10-Hz Voltage Noise**

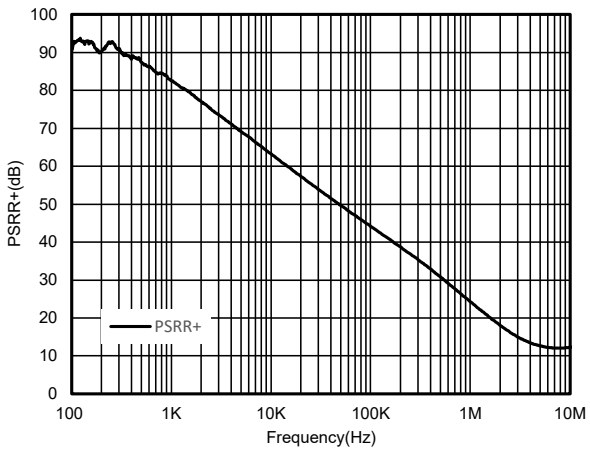



**Figure 5. PSRR+ vs. Frequency**

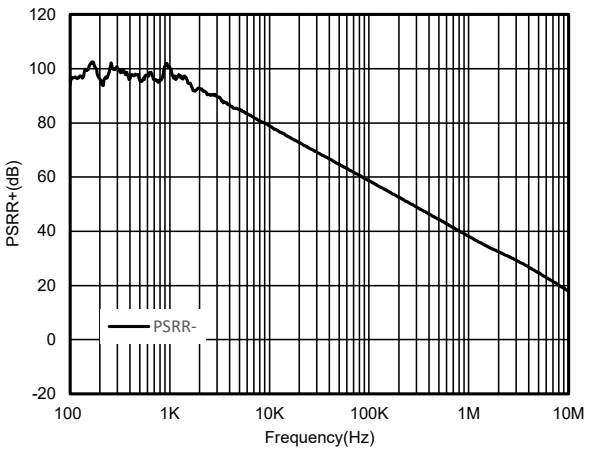



**Figure 6. PSRR− vs. Frequency**

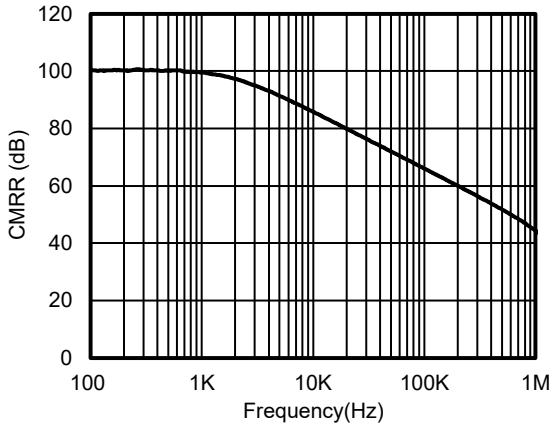



Figure 7. CMRR vs. Frequency

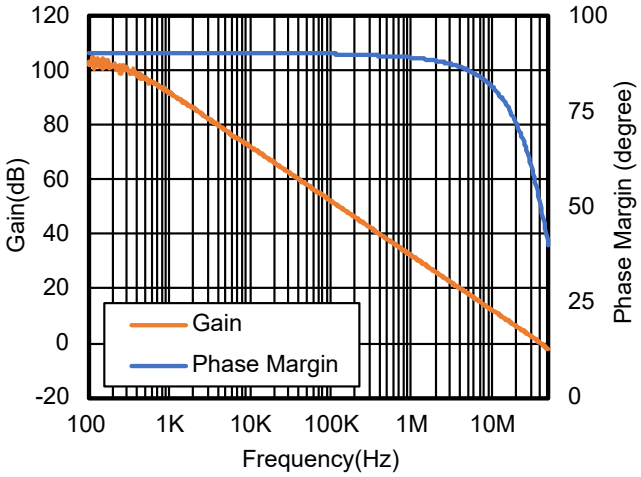



Figure 8. Open Loop Gain and Phase vs. Frequency

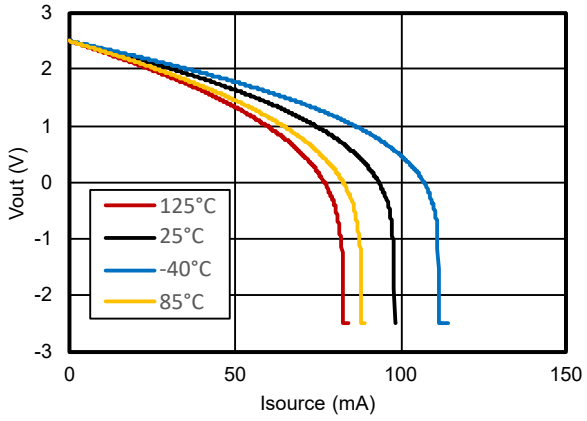



Figure 9. Output Voltage vs. Output Current, Source

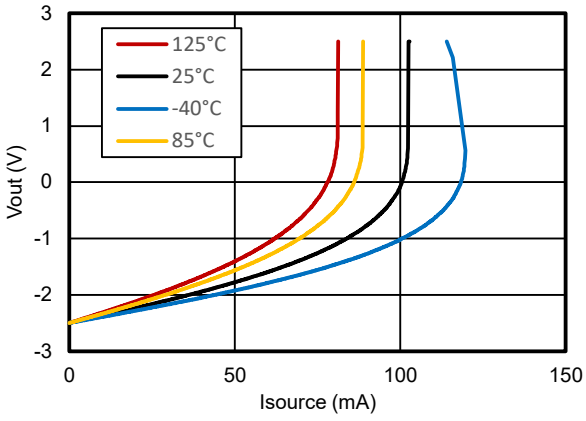



Figure 10. Output Voltage vs. Output Current, Sink

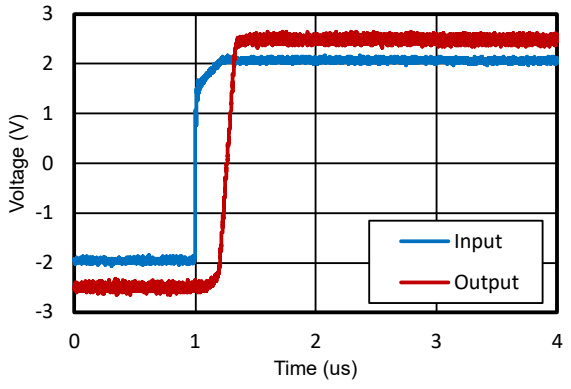



Figure 11. Overload Recovery Rise

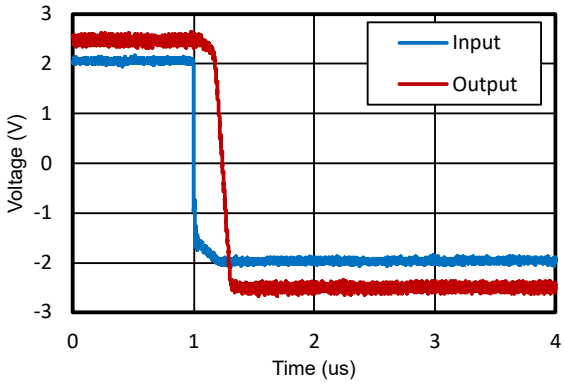



Figure 12. Overload Recovery Fall

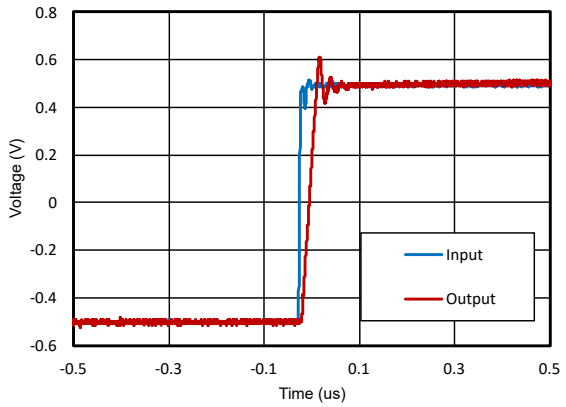



**Figure 13. Slew Rate Rise**

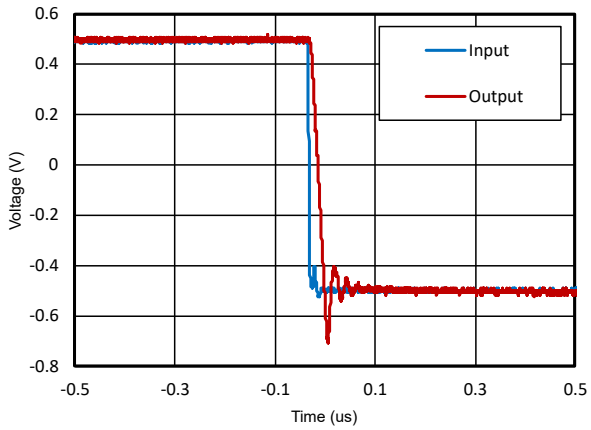



**Figure 14. Slew Rate Fall**

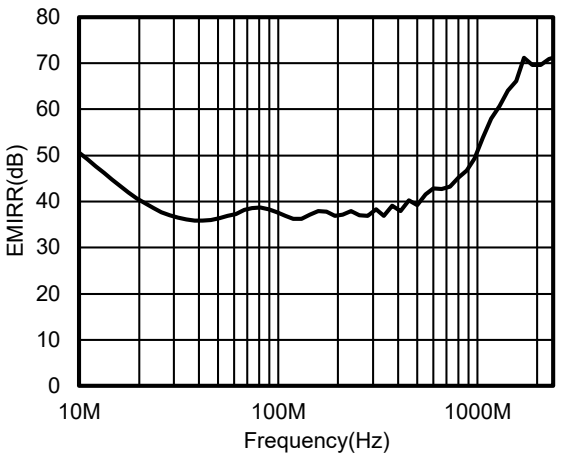



**Figure 15. EMIRR vs. Frequency**

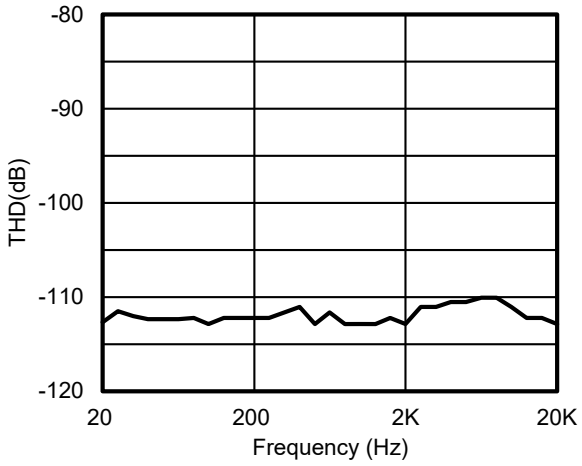



**Figure 16. THD vs. Frequency**

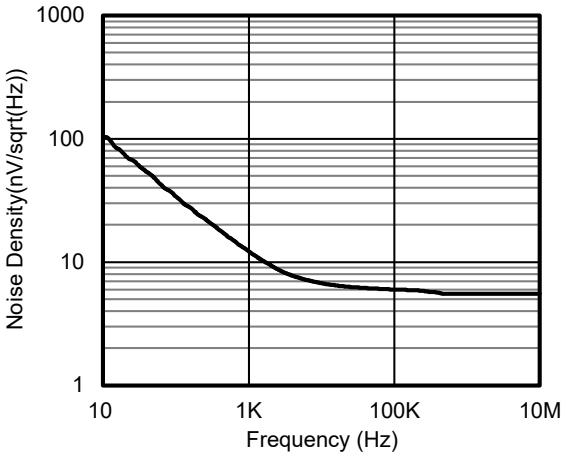



**Figure 17. Voltage Noise Spectral Density vs. Frequency**

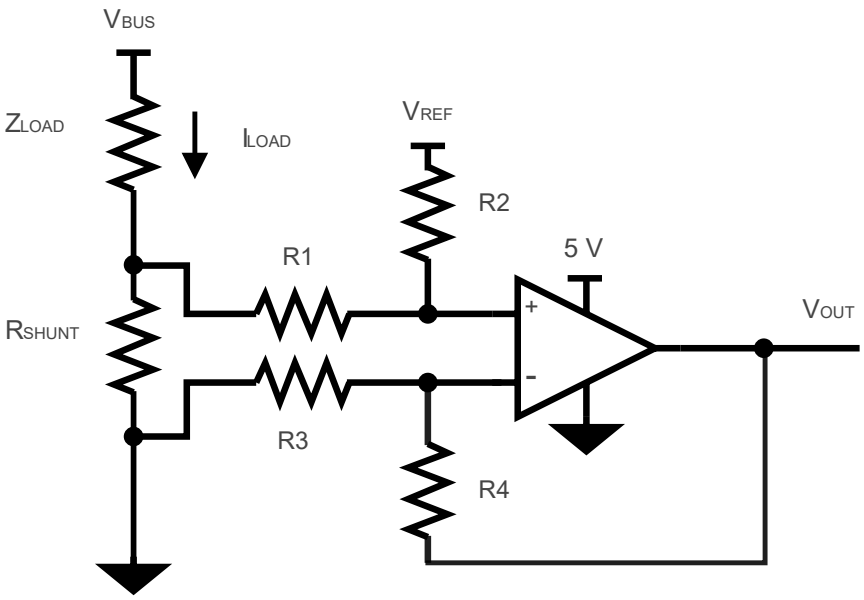
# Application and Implementation

> 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

### Low-side Current Sensing Application

Figure 18 shows the TPA599x configured in a low-side current sensing application. The low-side current sensing method consists of placing a sense resistor between the load and the circuit ground. The voltage dropping across the resistor is amplified by different amplifier circuits with the TPA599x. The $V_{REF}$ can be used to add bias voltage to the output voltage. Particular attention must be paid to the matching and precision of R1, R2, R3, and R4, to maximize the accuracy of the measurement.




$$V_{OUT} = (I_{LOAD} \times R_{SHUNT}) \times (R2 / R1) + V_{REF}$$

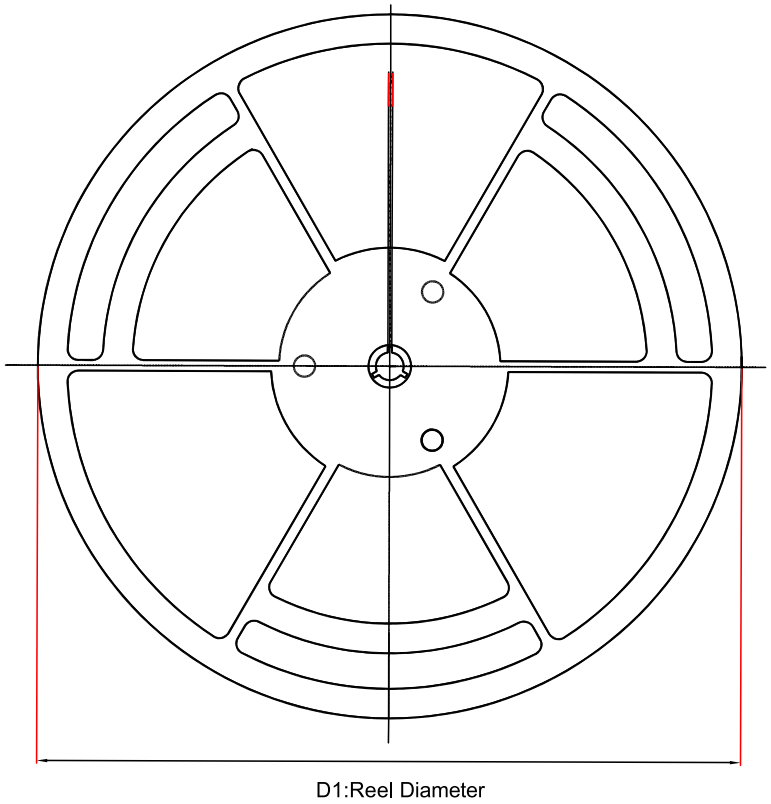
When R3 = R1, R2 = R4, $R_{SHUNT} << R1$

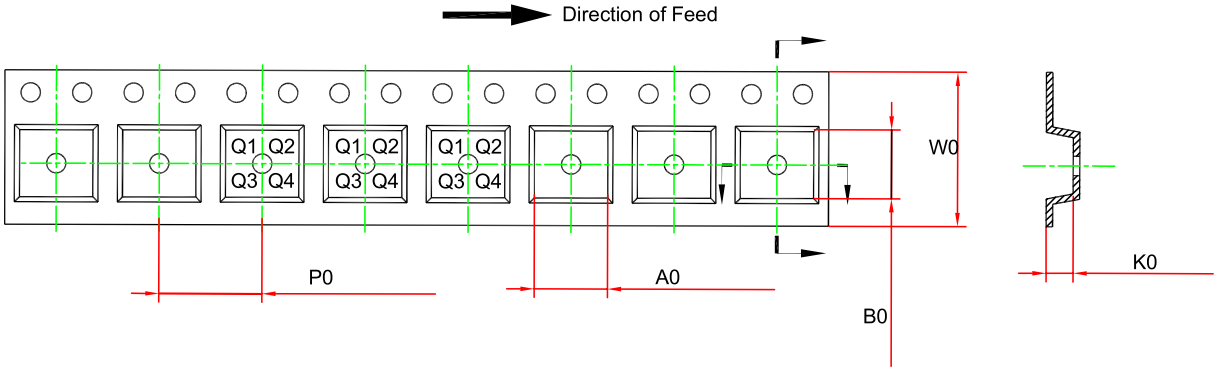
**Figure 18. Dual Supply Operation Connections**

### Power Supply Recommendations

Place 20-μF bypass capacitors close to the power supply pins to reduce coupling errors from the noisy or high impedance power supplies.

## Tape and Reel Information



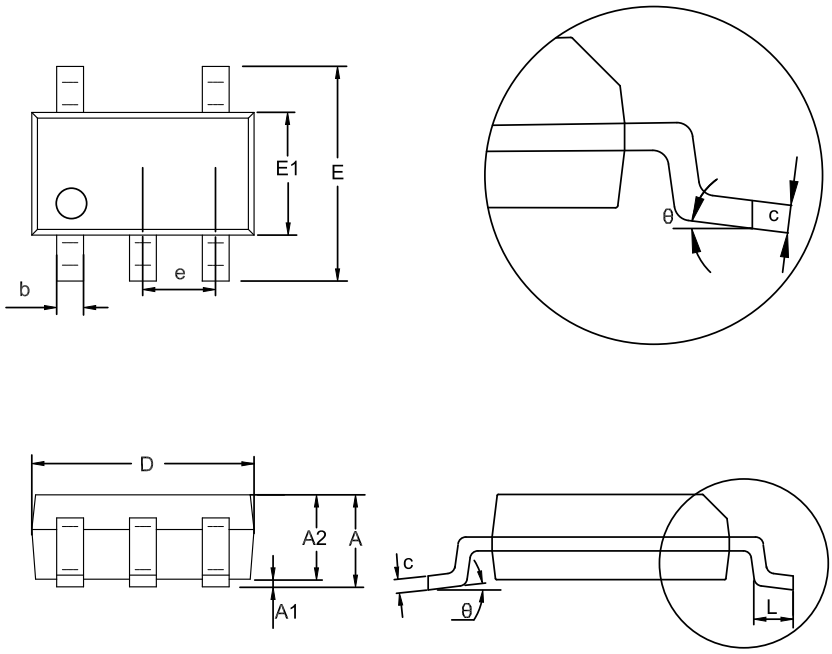

| Order Number | Package | D1 (mm) | W1 (mm) | A0 (mm) (1) | B0 (mm) (1) | K0 (mm) (1) | P0 (mm) | W0 (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|
| TPA5991-S5TR | SOT23-5 | 180.0 | 12 | 3.3 | 3.25 | 1.4 | 4.0 | 8.0 | Q3 |
| TPA5992-SO1R | SOP8 | 330.0 | 17.6 | 6.5 | 5.4 | 2 | 8.0 | 12.0 | Q1 |
| TPA5992-VS1R | MSOP8 | 330.0 | 17.6 | 5.3 | 3.4 | 1.3 | 8.0 | 12.0 | Q1 |
| TPA5992-WLPR | WLCSP | 179.0 | 12.2 | 1.6 | 2 | 0.85 | 4.0 | 8.0 | Q1 |

(1) The value is for reference only. Contact the 3PEAK factory for more information.

## Package Outline Dimensions

### SOT23-5

Package Outline Dimensions S5T(SOT23-5-A)



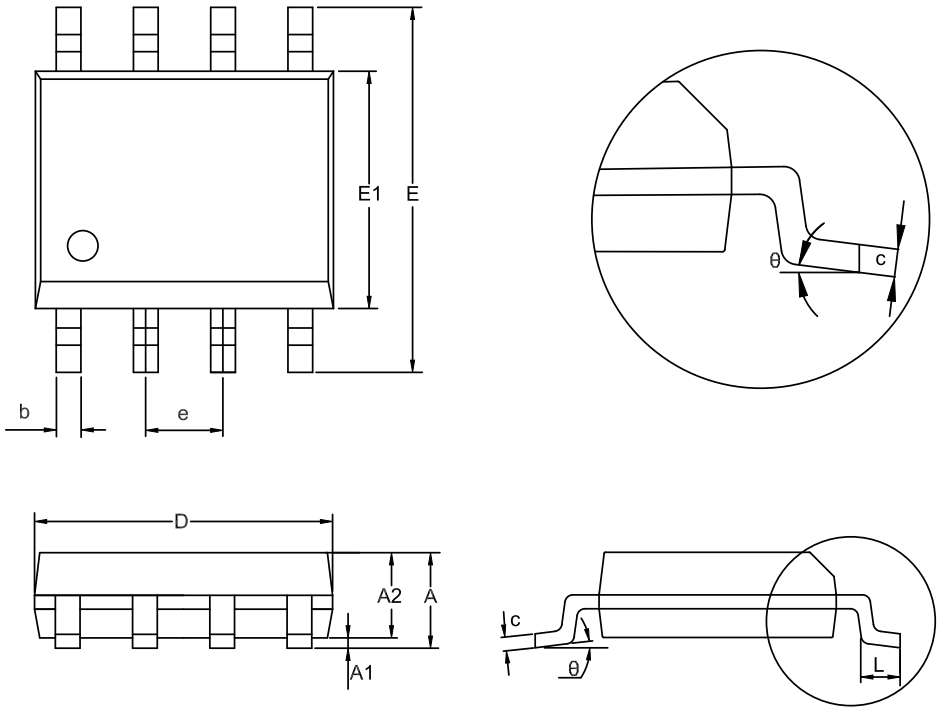

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.150 | 0.000 | 0.006 |
| A2 | 1.000 | 1.200 | 0.039 | 0.047 |
| b | 0.280 | 0.500 | 0.011 | 0.020 |
| c | 0.100 | 0.230 | 0.004 | 0.009 |
| D | 2.820 | 3.020 | 0.111 | 0.119 |
| E | 2.600 | 3.000 | 0.102 | 0.118 |
| E1 | 1.500 | 1.720 | 0.059 | 0.068 |
| e | 0.950 BSC | | 0.037 BSC | |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0 | 8° | 0 | 8° |

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

**SOP8**

## Package Outline Dimensions SO1(SOP-8-A)



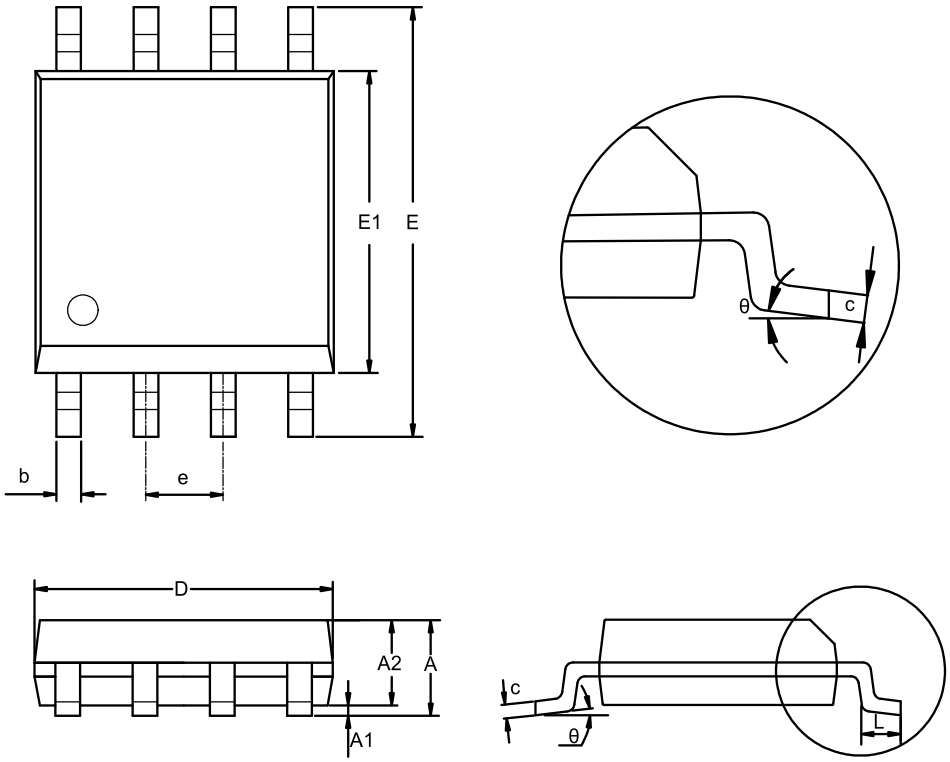

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.050 | 0.250 | 0.002 | 0.010 |
| A2 | 1.250 | 1.550 | 0.049 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.007 | 0.010 |
| D | 4.700 | 5.100 | 0.185 | 0.201 |
| E | 5.800 | 6.200 | 0.228 | 0.244 |
| E1 | 3.800 | 4.000 | 0.150 | 0.157 |
| e | 1.270 BSC | | 0.050 BSC | |
| L | 0.400 | 1.000 | 0.016 | 0.039 |
| θ | 0 | 8° | 0 | 8° |

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

**MSOP8**

## Package Outline Dimensions VS1(MSOP-8-A)



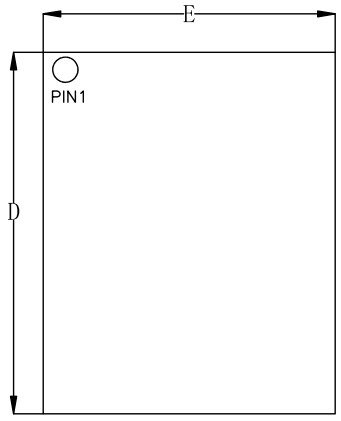

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.800 | 1.100 | 0.031 | 0.043 |
| A1 | 0.020 | 0.150 | 0.001 | 0.006 |
| A2 | 0.750 | 0.950 | 0.030 | 0.037 |
| b | 0.250 | 0.380 | 0.010 | 0.015 |
| c | 0.090 | 0.230 | 0.004 | 0.009 |
| D | 2.900 | 3.100 | 0.114 | 0.122 |
| E | 4.700 | 5.100 | 0.185 | 0.201 |
| E1 | 2.900 | 3.100 | 0.114 | 0.122 |
| e | 0.650 BSC | | 0.026 BSC | |
| L | 0.400 | 0.800 | 0.016 | 0.031 |
| θ | 0 | 8° | 0 | 8° |

NOTES

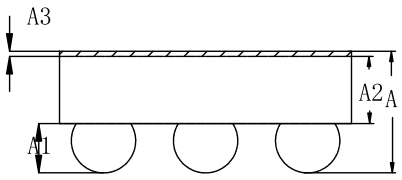
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

## WLCSP

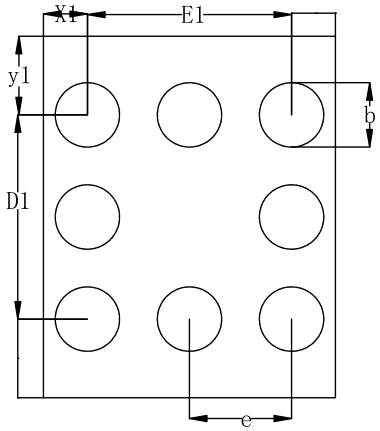
### Package Outline Dimensions WLP(WLCSP-A)




TOP VIEW
(MARK SIDE)




SIDE VIEW




BOTTOM VIEW
(BALL SIDE)

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.5635 | 0.6385 | 0.022 | 0.026 |
| A1 | 0.2260 | 0.2660 | 0.008 | 0.011 |
| A2 | 0.3175 | 0.3425 | 0.012 | 0.014 |
| A3 | 0.025 | | 0.001 | |
| b | 0.293 | 0.333 | 0.011 | 0.014 |
| D | 1.750 | 1.800 | 0.068 | 0.071 |
| D1 | 1.000 BSC | | 0.039 BSC | |
| E | 1.410 | 1.460 | 0.055 | 0.058 |
| E1 | 1.000 BSC | | 0.039 BSC | |
| e | 0.500 BSC | | 0.020 BSC | |
| x1 | 0.2175 REF | | 0.009 REF | |
| x2 | 0.2175 REF | | 0.009 REF | |
| y1 | 0.3875 REF | | 0.015 REF | |
| y2 | 0.3875 REF | | 0.015 REF | |

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.
3. The many types of E-pad Pin1 signs may appear in the product.

## Order Information

| Order Number | Operating Temperature Range | Package | Marking Information | MSL | Transport Media, Quantity | Eco Plan |
|---|---|---|---|---|---|---|
| TPA5991-S5TR | −40 to 125°C | SOT23-5 | AAX | 1 | Tape and Reel, 3000 | Green |
| TPA5992-SO1R | −40 to 125°C | SOP8 | A5992 | 1 | Tape and Reel, 4000 | Green |
| TPA5992-VS1R | −40 to 125°C | MSOP8 | A5992 | 1 | Tape and Reel, 3000 | Green |
| TPA5992-WLPR (1) | −40 to 125°C | WLCSP | AAS | 1 | Tape and Reel, 3000 | Green |

(1) For future products, contact the 3PEAK factory for more information and samples.

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

# IMPORTANT NOTICE AND DISCLAIMER



**Performance Information.** Performance tests or performance range contained in this document/material are either results of design simulation or actual tests conducted under designated testing environment. Any variation in testing environment or simulation environment, including but not limited to testing method, testing process or testing temperature, may affect actual performance of the product.

**Disclaimer.** 3PEAK provides technical and reliability data (including data sheets), design resources (including reference designs), application or other design recommendations, networking tools, security information and other resources "As Is". 3PEAK makes no warranty as to the absence of defects, and makes no warranties of any kind, express or implied, including without limitation, implied warranties as to merchantability, fitness for a particular purpose or non-infringement of any third-party's intellectual property rights. Unless otherwise specified in writing, products supplied by 3PEAK are not designed to be used in any life-threatening scenarios, including critical medical applications, automotive safety-critical systems, aviation, aerospace, or any situations where failure could result in bodily harm, loss of life, or significant property damage. 3PEAK disclaims all liability for any such unauthorized use.