

# Low-Input, Low-Dropout, 3-A Linear Regulator with Enable Control

## Features

- Input Voltage Range: 1.4 V to 6.5 V
- Adjustable Output Voltage: 0.5 V to 5.2 V
- $\pm 2\%$  Accuracy over Line Regulation, Load Regulation, and Operating Temperature Range
- 3-A Maximum Output Current
- Low Dropout Voltage: 300-mV Maximum at 3 A
- Output Enable Control
- Inherent Output Soft Start Control
- Excellent Transient Response
- High PSRR:
  - 63 dB at 1 kHz
  - 35 dB at 100 kHz
- 24- $\mu\text{V}_{\text{RMS}}$  Output Voltage Noise (100 Hz to 100 kHz)
- Stable with a 10- $\mu\text{F}$  Ceramic Output Capacitor
- Protection:
  - Over-Current Protection
  - Over-Temperature Protection
  - Output Short-to-Ground Protection
- Package:
  - ESOP8
- RoHS Compliant

## Applications

- Communication Infrastructure
- Telecom and Networking Cards
- Motherboards and Peripheral Cards
- Computing Systems

## Description

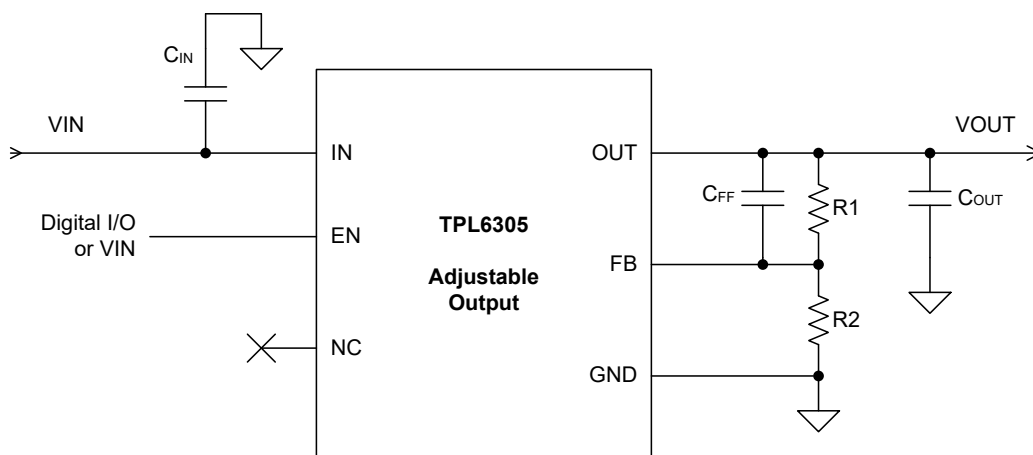
The TPL6305 is a 3-A high-current, 1.4-V low-input voltage linear regulator with only 300-mV maximum ultra-low-dropout voltage at full-load condition. The TPL6305 supports adjustable output voltage ranging from 0.5 V to 5.2 V with an external resistor divider.

Low-input voltage and ultra-low-dropout voltage make the TPL6305 the ideal power supply for applications requiring output voltage very close to the input voltage.

The TPL6305 integrates an enable control function and provides a very low standby power dissipation. The TPL6305 also provides output soft-start control and excellent transient response.

The TPL6305 provides a thermal-enhanced 8-pin ESOP package with guaranteed operating temperature ranging from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

## 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>10</b>
Overview.....	10
Functional Block Diagram.....	10
Feature Description.....	10
<b>Application and Implementation</b> .....	<b>13</b>
Application Information .....	13
Typical Application.....	13
<b>Layout</b> .....	<b>15</b>
Layout Guideline.....	15
<b>Tape and Reel Information</b> .....	<b>16</b>
<b>Package Outline Dimensions</b> .....	<b>17</b>
ESOP8-F.....	17
<b>Order Information</b> .....	<b>18</b>
<b>IMPORTANT NOTICE AND DISCLAIMER</b> .....	<b>19</b>

---

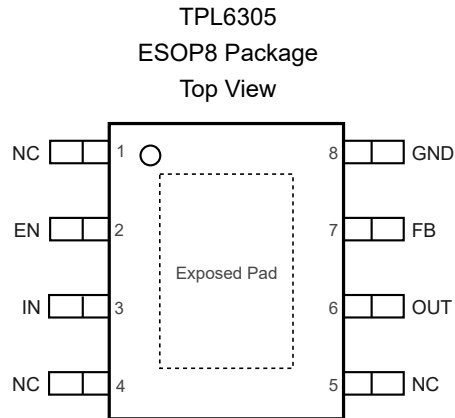
**Low-Input, Low-Dropout, 3-A Linear Regulator with Enable Control****Product Family Table**

Part Number	Output Voltage (V)	Package
TPL6305	Adjustable (0.5 V to 5.2 V)	ESOP8

**Revision History**

Date	Revision	Notes
2022-05-15	Rev.Pre.0	Preliminary Revision.
2022-10-31	Rev.Pre.1	Updated <a href="#">Electrical Characteristics</a> and <a href="#">Typical Performance Characteristics</a> .
2022-12-22	Rev.A.0	Initial Released.
2024-03-30	Rev.A.1	Updated thermal information.

## Pin Configuration and Functions



**Table 1. Pin Functions: TPL6305**

Pin No.	Pin Name	I/O	Description
2	EN	I	Regulator enable pin. Drive EN high to turn on the regulator; drive EN low to turn off the regulator. The EN pin must not be left floating.
7	FB	I	Output voltage feedback pin. Connect to an external resistor divider to adjust the output voltage. Although it is not required for stability, a 10-nF feed-forward capacitor from FB to OUT (as close as possible to FB pin) is recommended to improve regulator transient performance.
8	GND	-	Ground reference pin. Connect the GND pin to the PCB ground plane directly.
3	IN	I	Input voltage pin. Suggest connecting a 10- $\mu$ F or larger ceramic capacitor from IN to ground (as close as possible to the IN pin) to reduce the jitter from the previous-stage power supply.
1, 4, 5	NC	-	Not connected internally.
6	OUT	O	Regulated output voltage pin. A 10- $\mu$ F or greater ceramic capacitor from OUT to ground (as close as possible to OUT pin) is required to ensure regulator stability.
-	Exposed Pad	-	Exposed PAD must be connected to a large-area ground plane to maximize the thermal performance.

**Low-Input, Low-Dropout, 3-A Linear Regulator with Enable Control**
**Specifications**
**Absolute Maximum Ratings <sup>(1)</sup>**

Parameter		Min	Max	Unit
IN, EN		-0.3	7	V
OUT, FB		-0.3	$V_{IN} + 0.3$	V
T <sub>J</sub>	Junction Temperature Range	-40	150	°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.

(2) All voltage values are with respect to GND.

**ESD, Electrostatic Discharge Protection**

Parameter		Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±4	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 <sup>(2)</sup>	±1.5	kV

(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
IN	Input Voltage	1.4		6.5	V
EN	Enable Voltage	0		6.5	V
C <sub>OUT</sub>	Output Capacitor	10			μF
C <sub>FF</sub>	Feed-forward Capacitor		10		nF
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
ESOP8	31.66	10.27	45.44	°C/W

**Low-Input, Low-Dropout, 3-A Linear Regulator with Enable Control**
**Electrical Characteristics**

All test conditions:  $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  (typical value at  $T_J = +25^{\circ}\text{C}$ ),  $V_{IN} = V_{OUT(NOM)} + 0.4\text{ V}$  or  $1.4\text{ V}$ , whichever is greater;  $V_{EN} = 1.1\text{ V}$ ,  $V_{OUT(NOM)} = 0.5\text{ V}$ ,  $I_{OUT} = 1\text{ mA}$ ,  $C_{IN} = 10\text{ }\mu\text{F}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $C_{FF} = \text{open}$ , unless otherwise noted.

Parameter	Conditions	Min	Typ	Max	Unit
<b>Supply Voltage and Current</b>					
$V_{IN}$	Supply Voltage Range <sup>(1)</sup>	$V_{IN(MIN)}$		6.5	V
UVLO	Input Supply UVLO	$V_{IN}$ rising, $R_L = 1\text{ k}\Omega$		1.39	V
	Hysteresis		200		mV
$I_{GND}$	GND Current	$V_{IN} = 6.5\text{ V}$ , $I_{OUT} = 5\text{ mA}$	5	15	mA
		$V_{IN} = 6.5\text{ V}$ , $I_{OUT} = 3\text{ A}$	5	15	mA
$I_{SD}$	Shutdown Current	$V_{IN} = 6.5\text{ V}$ , $V_{EN} = 0\text{ V}$		68	$\mu\text{A}$
<b>Device Enable</b>					
$V_{IH(EN)}$	EN High-level Input Voltage	Device enable	1.1	6.5	V
$V_{IL(EN)}$	EN Low-level Input Voltage	Device disable	0	0.4	V
$I_{EN}$	EN Leakage Current	$V_{IN} = 6.5\text{ V}$ , $V_{EN} = 0\text{ V}$ to $6.5\text{ V}$	-0.5	0.5	$\mu\text{A}$
<b>Regulated Output Voltage and Current</b>					
$V_{FB}$	Feedback Voltage		-2%	0.5	+2%
$I_{FB}$	FB Pin Leakage Current	$V_{IN} = 6.5\text{ V}$ , stress $V_{FB} = 0.5\text{ V}$	-100		100
$V_{OUT}$	Output Accuracy <sup>(2)</sup>	$V_{IN} = V_{OUT(NOM)} + 0.4\text{ V}$ or $1.4\text{ V}$ to $6.5\text{ V}$ , $V_{OUT} = 0.5\text{ V}$ to $5.2\text{ V}$ , $I_{OUT} = 5\text{ mA}$ to $3\text{ A}$	-2%		+2%
$\Delta V_{OUT}$	Line Regulation	$V_{IN} = 1.4\text{ V}$ to $6.5\text{ V}$ , $I_{OUT} = 5\text{ mA}$		0.03	
	Load Regulation	$I_{OUT} = 5\text{ mA}$ to $3\text{ A}$		0.08	
$V_{DO}$	Dropout Voltage <sup>(3)</sup>	$V_{IN} = 1.4\text{ V}$ , $I_{OUT} = 1\text{ A}$ , $V_{FB} = 0.5\text{ V} - 3\%$		40	100
		$V_{IN} = 1.4\text{ V}$ , $I_{OUT} = 2\text{ A}$ , $V_{FB} = 0.5\text{ V} - 3\%$		80	200
		$V_{IN} = 1.4\text{ V}$ , $I_{OUT} = 3\text{ A}$ , $V_{FB} = 0.5\text{ V} - 3\%$		140	300
		$V_{IN} = 5.4\text{ V}$ , $I_{OUT} = 3\text{ A}$ , $V_{FB} = 0.5\text{ V} - 3\%$		145	300
		$V_{IN} = 5.6\text{ V}$ , $I_{OUT} = 3\text{ A}$ , $V_{FB} = 0.5\text{ V} - 3\%$		145	300
$I_{LIM}$	Output Current Limit	$V_{IN} = 1.4\text{ V}$ , $V_{OUT} = 0.9 \times V_{OUT(NOM)}$	3.7	4.7	A
$I_{SC}$	Short Circuit to Ground Current Limit Protection	$V_{OUT}$ is forced to ground, $T_A = 25^{\circ}\text{C}$		3	A
$t_{STR}$	Start-up Time	$V_{OUT} = 0\%$ to $90\%$ of $V_{OUT(NOM)}$		1	ms
PSRR	Power Supply Ripple Rejection	$V_{IN} = 5.5\text{ V}$ , $V_{OUT} = 5.2\text{ V}$ , $I_{OUT} = 2\text{ A}$ , $f = 1\text{ kHz}$		63	
		$V_{IN} = 5.5\text{ V}$ , $V_{OUT} = 5.2\text{ V}$ , $I_{OUT} = 2\text{ A}$ , $f = 100\text{ kHz}$		35	
$V_N$	Output Noise Voltage	$V_{IN} = 1.4\text{ V}$ , $V_{OUT} = 0.5\text{ V}$ , $I_{OUT} = 2\text{ A}$ , $BW = 100\text{ Hz}$ to $100\text{ kHz}$		24	$\mu\text{V}_{RMS}$

**Low-Input, Low-Dropout, 3-A Linear Regulator with Enable Control**

Parameter		Conditions	Min	Typ	Max	Unit
<b>Temperature Range</b>						
T <sub>SD</sub>	Thermal Shutdown Threshold	Temperature increasing		160		°C
	Hysteresis			20		°C

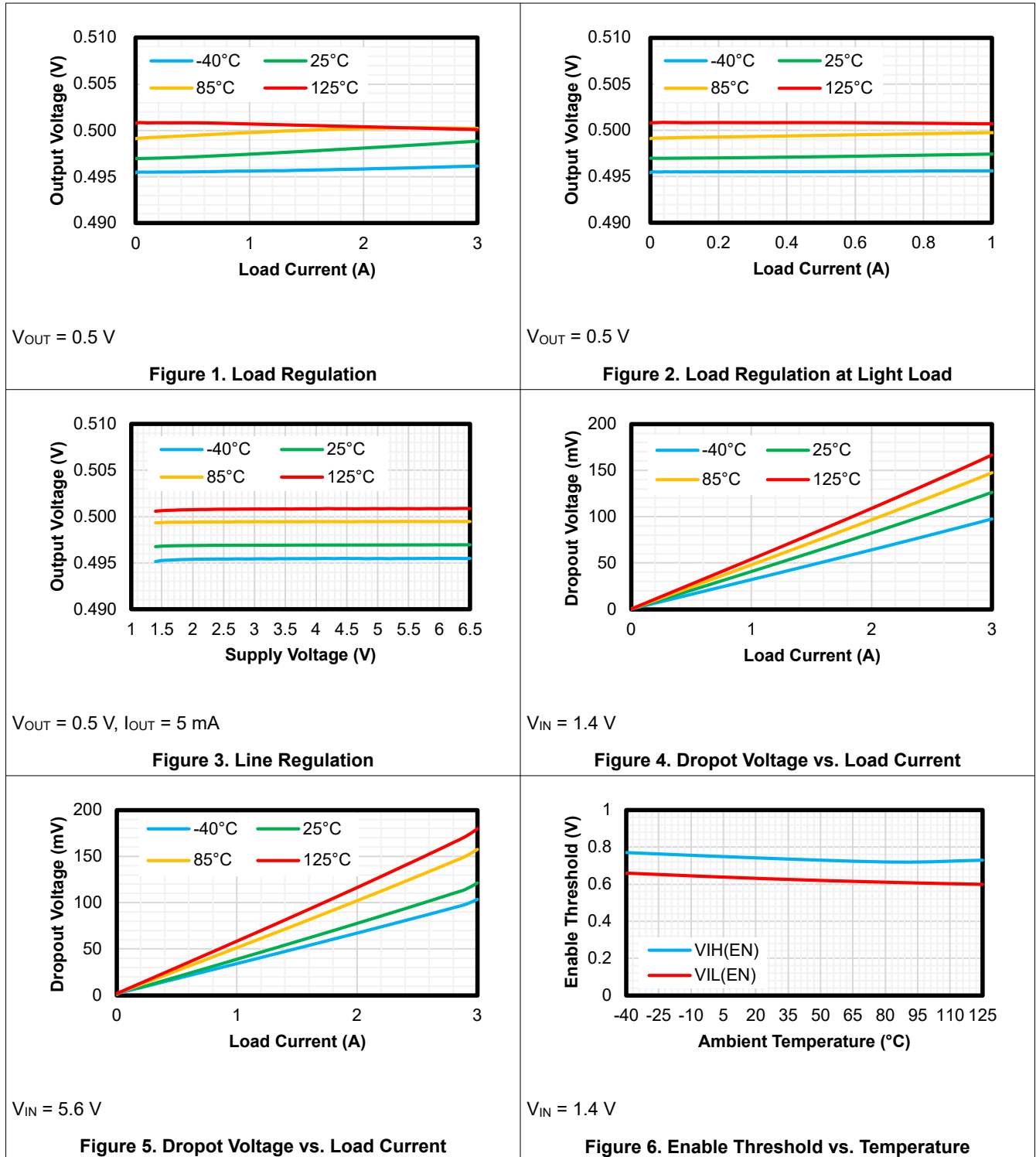
(1)  $V_{IN(MIN)} = V_{OUT(NOM)} + V_{DO}$  or 1.4 V, whichever is greater.

(2) Resistor tolerance is not included. Output accuracy is not tested at this condition:  $V_{OUT} = 0.5\text{ V}$ ,  $2.3\text{ V} \leq V_{IN} \leq 6.5\text{ V}$ , and  $500\text{ mA} \leq I_{OUT} \leq 3\text{ A}$ , because the power dissipation is out of package limitation.

(3) Dropout voltage is the minimum input to output voltage differential needed to maintain regulation at a specified output current and measure for  $V_{OUT(NOM)} \geq 1.4\text{ V}$ . In the dropout mode, the output voltage  $V_{OUT}$  will be equal to  $V_{IN} - V_{DO}$ .

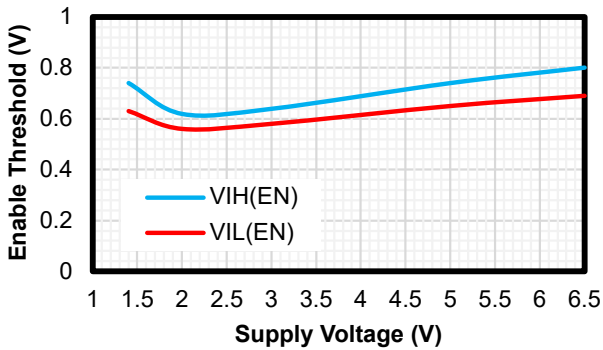
Typical Performance Characteristics

All test conditions:  $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  (typical value at  $T_J = +25^{\circ}\text{C}$ ),  $V_{IN} = V_{OUT(NOM)} + 0.4\text{ V}$  or  $1.4\text{ V}$ , whichever is greater;  $V_{EN} = 1.1\text{ V}$ ,  $V_{OUT(NOM)} = 0.5\text{ V}$ ,  $I_{OUT} = 1\text{ mA}$ ,  $C_{IN} = 10\text{ }\mu\text{F}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $C_{FF} = \text{open}$ , unless otherwise noted.



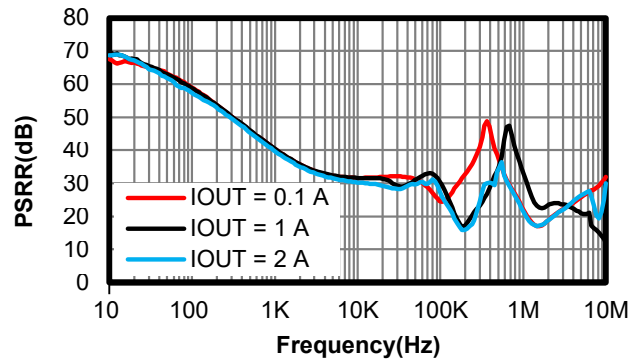


Low-Input, Low-Dropout, 3-A Linear Regulator with Enable Control



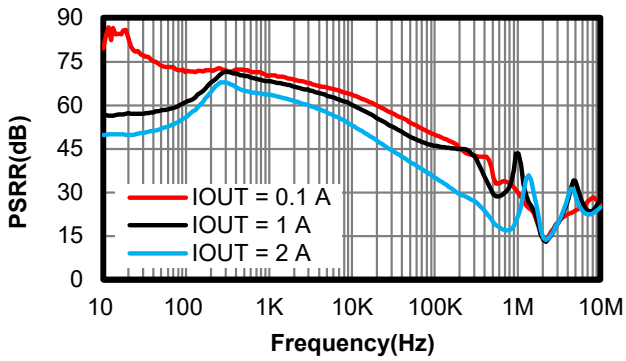
$T_A = 25^\circ\text{C}$

Figure 7. Enable Threshold vs. Supply Voltage



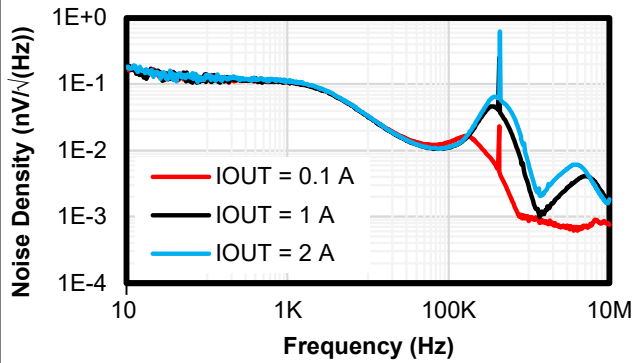
$V_{IN} = 1.4\text{ V}, V_{OUT} = 0.5\text{ V}$

Figure 8. PSRR



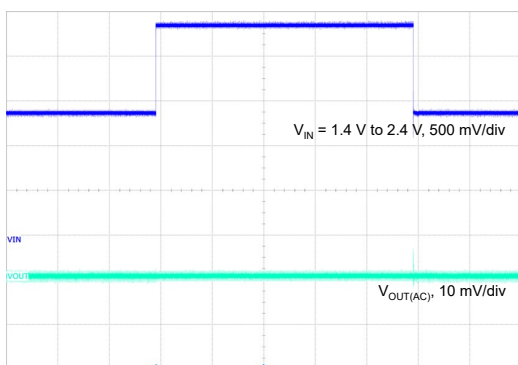
$V_{IN} = 5.5\text{ V}, V_{OUT} = 5.2\text{ V}$

Figure 9. PSRR



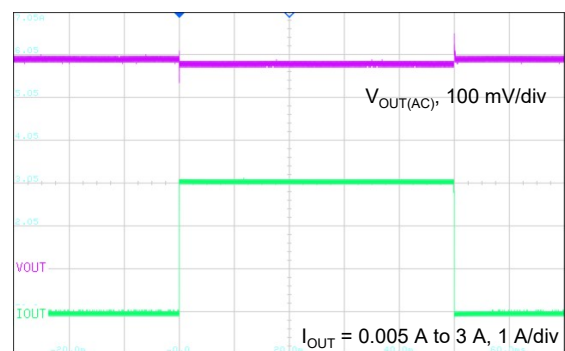
$V_{IN} = 1.4\text{ V}, V_{OUT} = 0.5\text{ V}$

Figure 10. Noise



$V_{IN} = 1.4\text{ V to } 2.4\text{ V}, V_{OUT} = 0.5\text{ V}$

Figure 11. Line Transient



$I_{OUT} = 0.1\text{ A to } 3\text{ A}, V_{OUT} = 0.5\text{ V}$

Figure 12. Load Transient

## Detailed Description

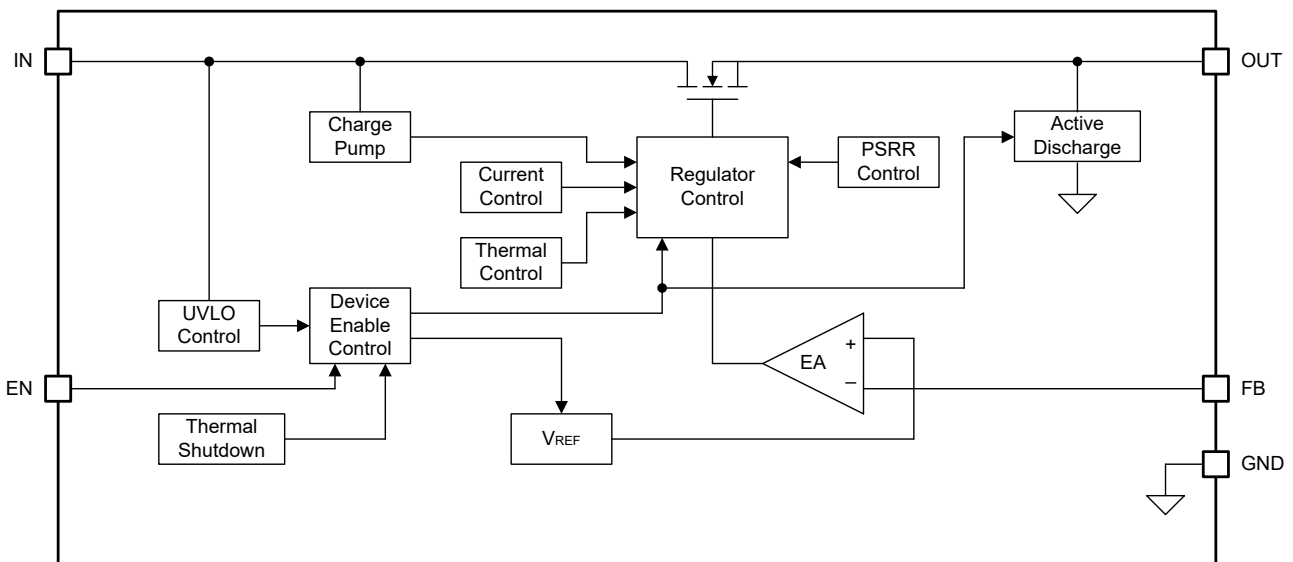
### Overview

The TPL6305 is a 3-A high-current, 1.4-V low-input voltage linear regulator with only 300-mV maximum ultra-low-dropout voltage at full-load condition. The TPL6305 supports adjustable output voltage ranging from 0.5 V to 5.2 V with an external resistor divider.

Low-input voltage and ultra-low-dropout voltage make the TPL6305 the ideal power supply for applications requiring output voltage very close to the input voltage.

The TPL6305 integrates an enable control function and provides a very low standby power dissipation. The TPL6305 also provides output soft-start control and excellent transient response.

### Functional Block Diagram



**Figure 13. Functional Block Diagram**

## Feature Description

### Enable (EN)

The TPL6305 provides a device enable pin (EN) to enable or disable the device. Connect this pin to the GPIO of an external digital logic control circuit to control the device. When the  $V_{EN}$  voltage falls below  $V_{IL(EN)}$ , the LDO device turns off, and when the  $V_{EN}$  ramps above  $V_{IH(EN)}$ , the LDO device turns on.

### Under-Voltage Lockout (UVLO)

The TPL6305 uses an under-voltage lockout circuit to keep the output shut off until the internal circuitry operates properly. Refer to the [Electrical Characteristics](#) table for the UVLO threshold and hysteresis.

### Adjustable Output Voltage (OUT and FB)

The TPL6305 is available in adjustable output voltage from 0.5 V to 5.2 V. The output voltage is determined by the value of the external resistor R1 and R2 in Figure 15. Use [Equation 1](#) to calculate the output voltage.

**Low-Input, Low-Dropout, 3-A Linear Regulator with Enable Control**

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

Where, the feedback voltage  $V_{FB}$  is 0.5 V.

Table 1 provides a list of recommended resistor combinations to achieve the common output voltage values.

**Table 2. External Resistor Combinations**

Target Output Voltage (V)	External Resistors Divider		Calculated Output Voltage (V)
	R1 (kΩ)	R2 (kΩ)	
0.50	0	Open	0.500
0.60	12.4	62	0.600
0.70	12.4	30.9	0.701
0.80	12	20	0.800
0.90	12	15	0.900
1.00	12.4	12.4	1.000
1.20	12.4	8.87	1.199
1.50	12.4	6.2	1.500
1.80	12.4	4.75	1.805
2.50	12	3	2.500
2.80	12	2.61	2.799
3.00	12	2.4	3.000
3.30	12.4	2.21	3.305
3.60	12.4	2	3.600
4.20	12	1.62	4.204
4.50	12	1.5	4.500
5.00	12	1.33	5.011

### Over-Current Protection

The TPL6305 integrates an internal current limit that helps to protect the regulator during fault conditions.

- When the output voltage is pulled down below the regulated voltage, over-current protection starts to work and limit the output current to  $I_{LIM}$ .
- When the output voltage is pulled down below the short-to-ground threshold (about 140 mV), or shorted to ground directly, short-to-ground protection starts to work and limit the output current to  $I_{SC}$ .
- During startup, the output current is limited to  $I_{SC}$  before the output voltage ramps higher than the short-to-ground threshold.

Under the over-current conditions, the internal junction temperature ramps up quickly. When the junction temperature is high enough, it will cause the over-temperature protection.

### Over-Temperature Protection

The over-temperature protection starts to work when the junction temperature exceeds the thermal shutdown (TSD) threshold, which turns off the regulator immediately. Until when the device cools down and the junction temperature falls below the value which equals to thermal shutdown threshold minus thermal shutdown hysteresis, the regulator turns on again.

---

**Low-Input, Low-Dropout, 3-A Linear Regulator with Enable Control**

The junction temperature range should be limited according to the [Recommended Operating Conditions](#) table, continuously operating above the junction temperature range will reduce the device lifetime.

## Application and Implementation

### Note

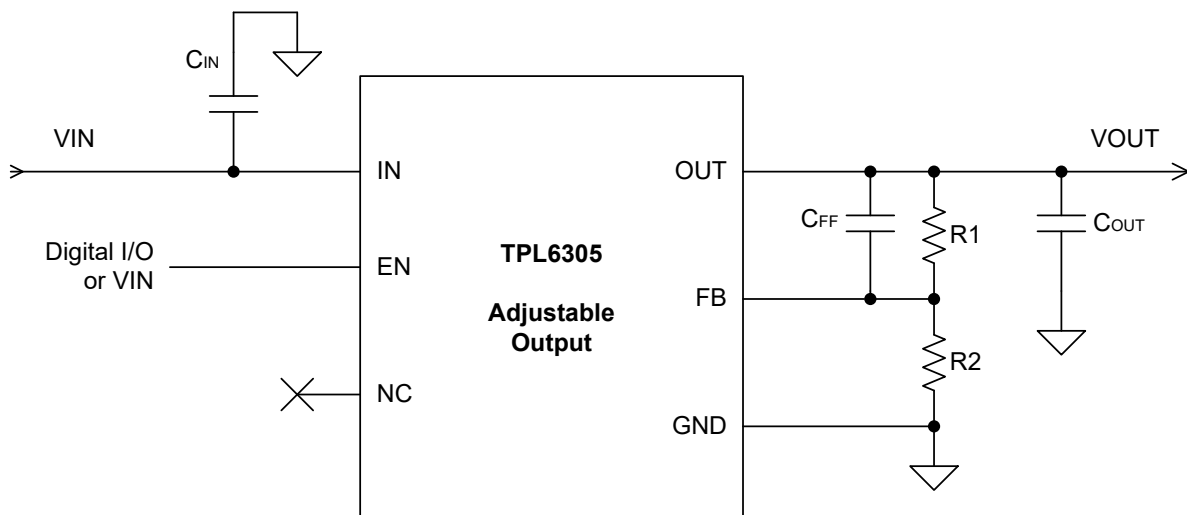
Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design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

## Application Information

The TPL6305 is a 3-A high-current, 1.4-V low-input voltage linear regulator with only 300-mV maximum ultra-low-dropout voltage at full-load condition. The following application schematic shows a typical usage of TPL6305.

## Typical Application

Figure 14 shows the typical application schematic of the TPL6305.



**Figure 14. Typical Application Circuit**

### Input Capacitor and Output Capacitor

The TPL6305 is designed to be stable with low equivalent series resistance (ESR) ceramic capacitors at the input, output, and noise-reduction pin (NR/SS). It is recommended to use ceramic capacitors with X7R-, X5R-, and COG-rated dielectric materials to get good capacitive stability across temperature.

3PEAK recommends adding a 10- $\mu$ F or greater capacitor with a 0.1- $\mu$ F bypass capacitor in parallel at the IN pin to keep the input voltage stable. The voltage rating of the capacitors must be greater than the maximum input voltage.

To ensure loop stability, the TPL6305 requires a minimum value of 10- $\mu$ F low ESR output capacitor. 3PEAK recommends selecting an X7R-type 10- $\mu$ F ceramic capacitor with low ESR over temperature.

Both input capacitors and output capacitors must be placed as close to the device pins as possible.

### Power Dissipation

During normal operation, LDO junction temperature should meet the requirement in the [Recommended Operating Conditions](#) table. Using below two equations to calculate the power dissipation and estimate the junction temperature.

---

**Low-Input, Low-Dropout, 3-A Linear Regulator with Enable Control**

The power dissipation can be calculated using [Equation 2](#).

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_{GND} \quad (2)$$

The junction temperature can be estimated using [Equation 3](#).  $\theta_{JA}$  is the junction-to-ambient thermal resistance.

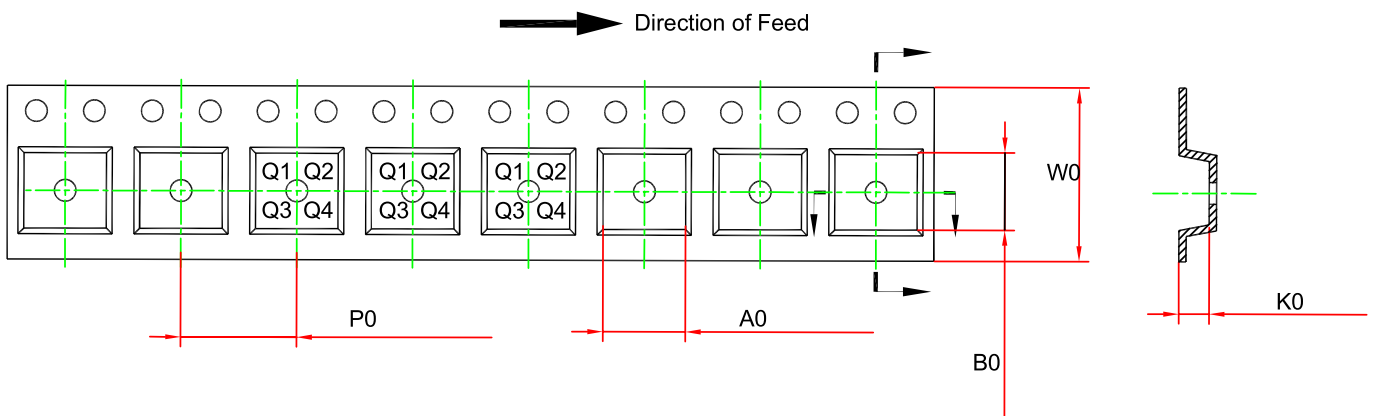
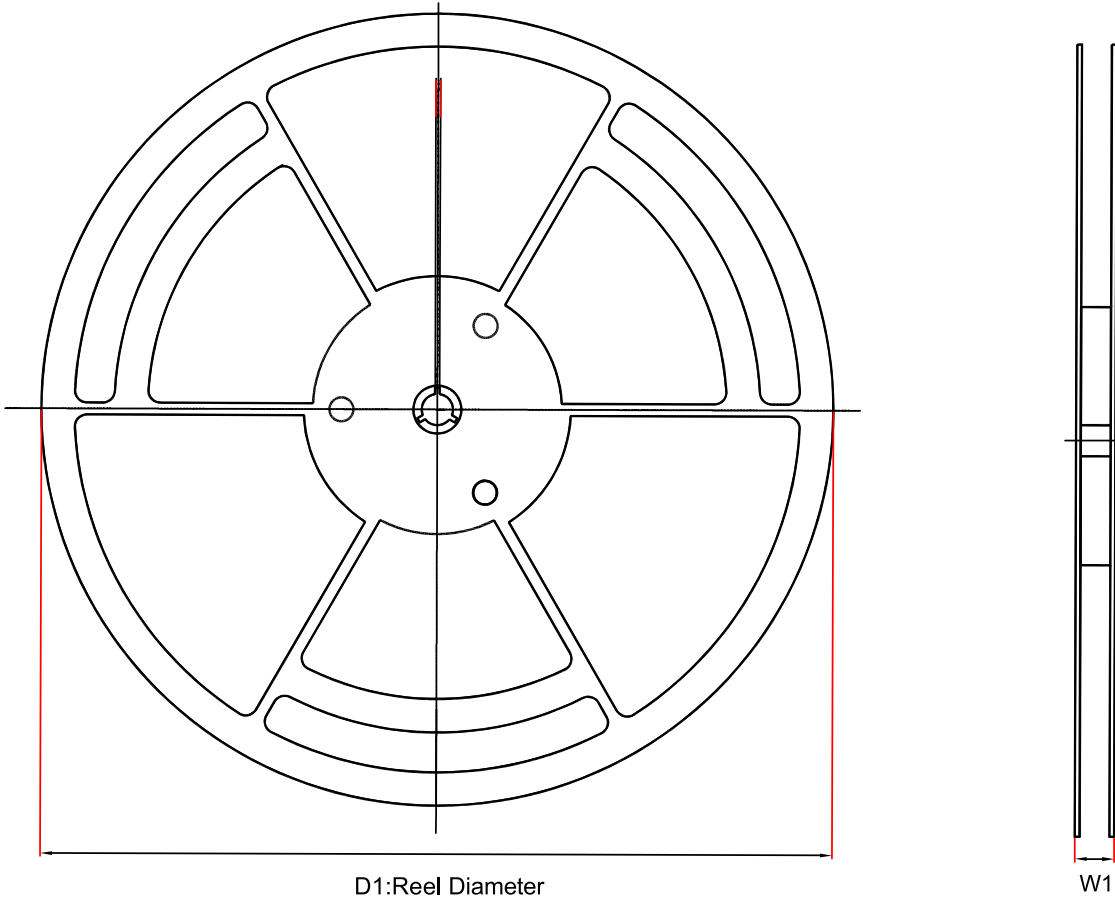
$$T_J = T_A + P_D \times \theta_{JA} \quad (3)$$

## Layout

### Layout Guideline

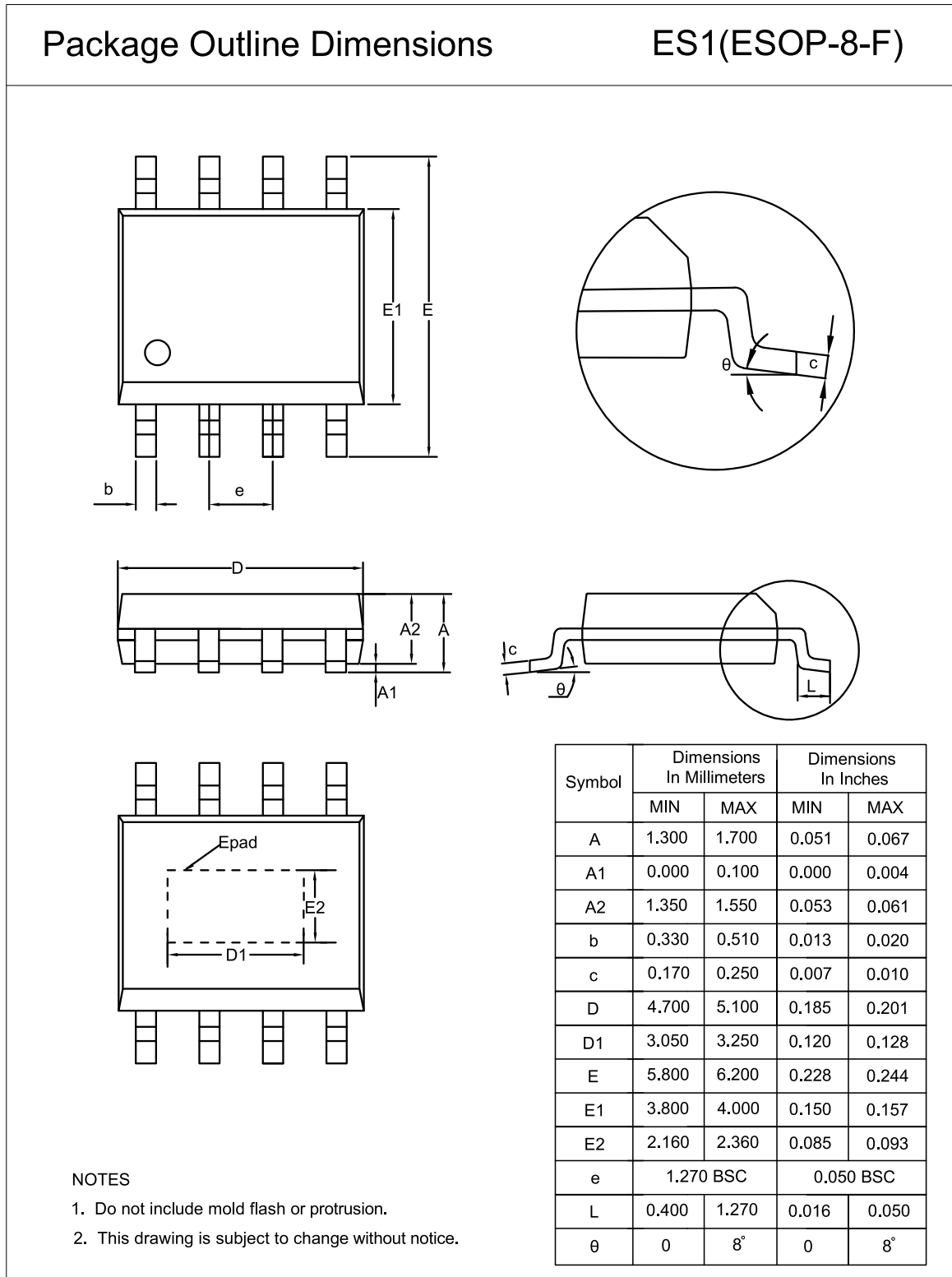
- Both input capacitors and output capacitors must be placed to the device pins as close as possible, and the vias between capacitors and device power pins must be avoided.
- It is recommended to bypass the input pin to ground with a 0.1- $\mu$ F bypass capacitor. The loop area formed by the bypass capacitor connection, the IN pin and the GND pin of the system must be as small as possible.
- It is recommended to use wide and thick copper to minimize I $\times$ R drop and heat dissipation.
- Exposed pad must be connected to the PCB ground plane directly, the copper area must be as large as possible.

Tape and Reel Information



Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPL6305AD-ES1R	ESOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1



**Package Outline Dimensions**
**ESOP8-F**


---

**Low-Input, Low-Dropout, 3-A Linear Regulator with Enable Control****Order Information**

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPL6305AD-ES1R	-40°C to +125°C	ESOP8	L635A	MSL3	Tape and Reel, 4,000	Green

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

## **IMPORTANT NOTICE AND DISCLAIMER**

**Copyright**© 3PEAK 2012-2024. All rights reserved.

**Trademarks.** Any of the 思瑞浦 or 3PEAK trade names, trademarks, graphic marks, and domain names contained in this document /material are the property of 3PEAK. You may NOT reproduce, modify, publish, transmit or distribute any Trademark without the prior written consent of 3PEAK.

**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.

This page intentionally left blank