

## 3-A Output, High-PSRR, Low-Noise LDO Regulator

### Features

- Input Voltage Range
  - Without BIAS: 1.4 V to 6.5 V
  - With BIAS: 1.1 V to 6.5 V
- Output Voltage Options:
  - Fixed Output Voltage: 0.5 V to 3.65 V
  - Adjustable Output Voltage: 0.5 V to 5.2 V
- $\pm 1\%$  Output Accuracy over Line Regulation, Load Regulation, and Operating Temperature Range With BIAS
- 3-A Maximum Output Current
- Low Dropout Voltage: 300 mV Maximum at 3 A
- High PSRR:
  - 65 dB at 1 kHz
  - 60 dB at 1 MHz
- $4\text{-}\mu\text{V}_{\text{RMS}}$  Output Voltage Noise
- Excellent Transient Response
- Enable and Adjustable Soft-Start Control
- Open-Drain Power-Good (PG) Output
- Stable with 10- $\mu\text{F}$  or Greater Ceramic Output Capacitor
- Over-Current Protection
- Over-Temperature Protection
- Temperature Range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- Package Options:
  - QFN3.5X3.5-20

### Applications

- Wireless Communication: CPU, ASIC, FPGA, CPLD, DSP
- High-Performance Analog: ADC, DAC, LVDS, VCO
- Noise-Sensitive Imaging: CMOS Sensors, Video ASICs

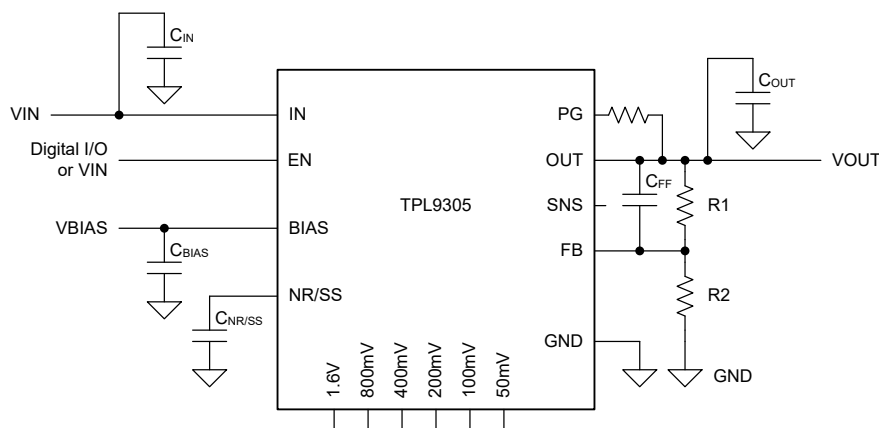
### Description

The TPL9305 is a 3-A high-current,  $4\text{-}\mu\text{V}_{\text{RMS}}$  low-noise, high-PSRR, high-accuracy linear regulator with maximum 300-mV ultra-low dropout voltage at 3-A load condition. The TPL9305 supports both fixed output voltage ranging from 0.5 V to 3.65 V and adjustable output voltage ranging from 0.5 V to 5.2 V with an external resistor divider.

Ultra-low noise, high PSRR, and high-output-current capabilities make the TPL9305 an ideal power supply for noise-sensitive applications, such as high-speed communication facilities, test and measurement devices, or high-definition imaging equipment. Accurate output voltage tolerance, output voltage remote sensing, excellent transient response, and adjustable soft-start control ensure the TPL9305 an optimal power supply for the large-scale processors or digital loads, such as ASIC, FPGA, CPLD, and DSP.

The TPL9305 provides a 20-pin QFN3.5X3.5 package with guaranteed operating junction temperature ranging ( $T_J$ ) from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

### Typical Application Circuit



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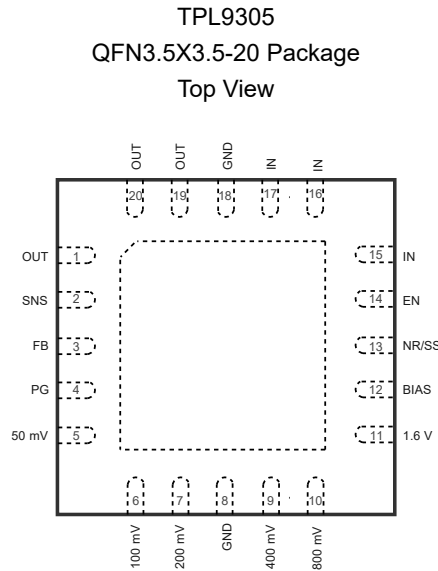
## Product Family Table

Order Number	Output Voltage (V)	Package
TPL9305AD-QF6R-S	Adjustable (0.5 V to 5.2 V)	QFN3.5X3.5-20

## Revision History

Revision	Notes
Rev.Pre.0	Preliminary revision.
Rev.A.0	Initial released.
Rev.A.1	Corrected data in <a href="#">Electrical Characteristics</a> , <a href="#">Typical Performance Characteristics</a> and <a href="#">Feature Description</a> .

## Pin Configuration and Functions



**Table 1. Pin Functions: TPL9305**

Pin No.	Pin Name	I/O	Description
5, 6, 7, 9, 10, 11	50mV, 100mV, 200mV, 400mV, 800mV, 1.6V	I	Fixed output voltage configuration pins. Connect these pins to ground to increase the output voltage. Leave these pins open when using the external resistor divider.
12	BIAS	I	BIAS input pin. A 10- $\mu$ F capacitor or larger must be connected between this pin and ground. Leave BIAS pin open or tied to ground when not used.
14	EN	I	Regulator enable pin. Drive EN high to turn on the regulator; drive EN low to turn off the regulator.
3	FB	I	Output voltage feedback pin. Connect to an external resistor divider to adjust the output voltage. A 10-nF feed-forward capacitor from FB to OUT (as close as possible to FB pin) is recommended to maximize regulator ac performance.
8, 18	GND	–	Ground reference pin. Connect the GND pin to PCB ground plane directly.
15, 16, 17	IN	I	Input supply pin. A 10- $\mu$ F or greater ceramic capacitor from IN to ground (as close as possible to IN pin) is required.
13	NR/SS	I	Noise-reduction and soft-start control pin. A 10-nF or greater capacitor from NR/SS to GND (as close as possible to NR/SS pin) is required.
1, 19, 20	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.
4	PG	O	Open-drain power-good output pin. Leave the PG pin open when not used.
2	SNS	I	Output voltage sense input pin. Connect this pin to the load side of the output trace only when using the fixed output voltage. Leave SNS pin open when using the external resistor divider.

(1) Exposed PAD must be connected to a large-area ground plane to maximize the thermal performance.

## Specifications

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

Parameter		Min	Max	Unit
IN, BIAS, EN, PG		-0.3	7	V
OUT, SNS		-0.3	$V_{IN} + 0.3$	V
NR/SS, FB		-0.3	3.6	V
50 mV, 100 mV, 200 mV, 400 mV, 800 mV, 1.6 V		-0.3	$V_{OUT} + 0.3$	V
T <sub>J</sub>	Maximum Junction Temperature	-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	1.1		6.5	V
BIAS	BIAS Voltage	3		6.5	V
EN	Enable Voltage	0		6.5	V
OUT	Output Voltage	0.5		5.2	V
C <sub>IN</sub>	Input Capacitor	10			μF
C <sub>OUT</sub>	Output Capacitor	10	22		μF
C <sub>FF</sub>	Feed-forward Capacitor		10	1000	nF
C <sub>NR/SS</sub>	NR/SS Capacitor		10		nF
R <sub>PG</sub>	Power-good Pull-up Resistor	10		100	kΩ
R <sub>1</sub>	High-Side Resistor of the Resistor Divider		12.1		kΩ
R <sub>2</sub>	Low-Side Resistor of the Resistor Divider			160	kΩ
T <sub>J</sub>	Junction Temperature Range	-40		125	°C

### Thermal Information

Package Type	θ <sub>JA</sub>	θ <sub>JC,BOTTOM</sub>	Unit
QFN3.5X3.5-20	41.2	16.3	°C/W

**3-A Output, High-PSRR, Low-Noise LDO Regulator**
**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;  $V_{BIAS} = \text{open}$ ,  $V_{OUT(NOM)} = 0.5\text{ V}$ ,  $V_{EN} = 1.1\text{ V}$ ,  $C_{IN} = 10\ \mu\text{F}$ ,  $C_{OUT} = 10\ \mu\text{F}$ ,  $C_{NR/SS} = 0\text{ nF}$ ,  $C_{FF} = 0\text{ nF}$ , OUT connect to  $50\ \Omega$  to ground, PG connected to  $100\text{ k}\Omega$  to OUT, unless otherwise noted.

Parameter	Conditions	Min	Typ	Max	Unit
<b>Supply Input Voltage and Current</b>					
$V_{IN}^{(1)}$	Input Voltage Range	1.1		6.5	V
$V_{BIAS}$	Bias Voltage Range	$V_{IN} = 1.1\text{ V}$		6.5	V
$UVLO_{IN1}$	$V_{IN}$ UVLO with BIAS	$V_{IN}$ rising with $V_{BIAS} = 3\text{ V}$		1.09	V
	Hysteresis	$V_{BIAS} = 3\text{ V}$	200		mV
$UVLO_{IN2}$	$V_{IN}$ UVLO without BIAS	$V_{IN}$ rising		1.39	V
	Hysteresis		200		mV
$UVLO_{BIAS}$	$V_{BIAS}$ UVLO	$V_{BIAS}$ rising, $V_{IN} = 1.1\text{ V}$		2.9	V
	Hysteresis	$V_{IN} = 1.1\text{ V}$	200		mV
$I_{GND}$	Ground Current	$V_{IN} = 6.5\text{ V}$ , $I_{OUT} = 5\text{ mA}$	5	15	mA
		$V_{IN} = 1.4\text{ V}$ , $I_{OUT} = 3\text{ A}$	5	15	mA
		$V_{IN} = 1.1\text{ V}$ , $V_{BIAS} = 3\text{ V}$ , $I_{OUT} = 3\text{ A}$	5	15	mA
$I_{SD}$	Shutdown Current	$V_{IN} = 6.5\text{ V}$ , $V_{EN} = 0.4\text{ V}$ , PG = open		68	$\mu\text{A}$
$I_{BIAS}$	BIAS Pin Current	$V_{IN} = 1.1\text{ V}$ , $V_{BIAS} = 6.5\text{ V}$ , $I_{OUT} = 3\text{ A}$	2.5	5	mA
<b>Enable and Power Good</b>					
$V_{IH(EN)}$	EN High-Level Input	Device enable	1.1	6.5	V
$V_{IL(EN)}$	EN Low-Level Input	Device disable	0	0.4	V
$I_{EN}$	EN Leakage Current	$V_{IN} = 6.5\text{ V}$ , $V_{EN} = 0\text{ V}$ to $6.5\text{ V}$	-0.2	0.2	$\mu\text{A}$
$V_{PG}$	PG Threshold	$V_{OUT}$ falling		81%	$\times V_{OUT}$
	Hysteresis			2%	$\times V_{OUT}$
$V_{OL(PG)}$	PG Low-Level Output	$V_{OUT} < V_{PG}$ , source $1\text{ mA}$ to PG pin		0.4	V
$I_{PG}$	PG Leakage Current	$V_{OUT} > V_{PG}$ , apply $6.5\text{ V}$ at PG pin		1	$\mu\text{A}$

(1) Minimum  $V_{IN} = V_{OUT(NOM)} + V_{DO}$  or  $1.4\text{ V}$  or  $1.1\text{ V}$  with  $V_{BIAS} = 3\text{ V}$ , whichever is greater.

**3-A Output, High-PSRR, Low-Noise LDO Regulator**
**Electrical Characteristics (Continued)**

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;  $V_{BIAS} = \text{open}$ ,  $V_{OUT(NOM)} = 0.5\text{ V}$ ,  $V_{EN} = 1.1\text{ V}$ ,  $C_{IN} = 10\text{ }\mu\text{F}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $C_{NR/SS} = 0\text{ nF}$ ,  $C_{FF} = \text{open}$ , OUT connect to  $50\text{ }\Omega$  to ground, PG connected to  $100\text{ k}\Omega$  to OUT, unless otherwise noted.

Parameter	Conditions	Min	Typ	Max	Unit	
<b>Regulated Output Voltage and Current</b>						
$V_{FB}$	Feedback Voltage		0.5		V	
$I_{FB}$	FB Leakage Current	$V_{IN} = 6.5\text{ V}$ , stress $V_{FB} = 0.5\text{ V}$	-100	100	nA	
$V_{NR/SS}$	NR/SS Voltage		0.5		V	
$I_{NR/SS}$	NR/SS Charging Current	$V_{IN} = 6.5\text{ V}$ , $V_{NR/SS} = \text{GND}$	6	7.8	9	$\mu\text{A}$
$V_{OUT}$	Output Voltage Range	Fixed	0.5	3.65	V	
		Adjustable	0.5	5.2	V	
	Accuracy <sup>(1)(2)</sup>	$V_{OUT} = 0.5\text{ V}$ to $5.2\text{ V}$ , $I_{OUT} = 5\text{ mA}$ to $3\text{ A}$	-1%	1%		
$\Delta V_{OUT}$	Line Regulation	$V_{IN} = 1.4\text{ V}$ to $6.5\text{ V}$ , $I_{OUT} = 5\text{ mA}$		0.03	mV/V	
	Load Regulation	$V_{IN} = 1.1\text{ V}$ , $V_{BIAS} = 3\text{ V}$ to $6.5\text{ V}$ , $I_{OUT} = 5\text{ mA}$ to $3\text{ A}$		0.7	mV/A	
		$I_{OUT} = 5\text{ mA}$ to $3\text{ A}$		0.8	mV/A	
$V_{DO}$	Dropout Voltage without BIAS	$V_{IN} = 1.4\text{ V}$ , $I_{OUT} = 1\text{ A}$ , $V_{FB} = 0.5\text{ V} - 3\%$		40	100	mV
		$V_{IN} = 1.4\text{ V}$ , $I_{OUT} = 2\text{ A}$ , $V_{FB} = 0.5\text{ V} - 3\%$		80	200	mV
		$V_{IN} = 1.4\text{ V}$ , $I_{OUT} = 3\text{ A}$ , $V_{FB} = 0.5\text{ V} - 3\%$		120	300	mV
		$V_{IN} = 5.6\text{ V}$ , $I_{OUT} = 3\text{ A}$ , $V_{FB} = 0.5\text{ V} - 3\%$		120	300	mV
	Dropout Voltage with BIAS	$V_{IN} = 1.1\text{ V}$ , $V_{BIAS} = 5\text{ V}$ , $I_{OUT} = 1\text{ A}$ , $V_{FB} = 0.5\text{ V} - 3\%$		40	100	mV
		$V_{IN} = 1.1\text{ V}$ , $V_{BIAS} = 5\text{ V}$ , $I_{OUT} = 2\text{ A}$ , $V_{FB} = 0.5\text{ V} - 3\%$		80	200	mV
$V_{IN} = 1.1\text{ V}$ , $V_{BIAS} = 5\text{ V}$ , $I_{OUT} = 3\text{ A}$ , $V_{FB} = 0.5\text{ V} - 3\%$			120	300	mV	
$I_{LIM}$	Output Current Limit	$V_{OUT}$ forced at $0.9 \times V_{OUT(NOM)}$	3.7	4.7	A	
<b>PSRR and Noise</b>						
PSRR	Power Supply Ripple Rejection	$I_{OUT} = 3\text{ A}$ , $C_{NR/SS} = 100\text{ nF}$ , $C_{FF} = 100\text{ nF}$ , $C_{OUT} = 47\text{ }\mu\text{F} \parallel 10\text{ }\mu\text{F} \parallel 10\text{ }\mu\text{F}$	$f = 1\text{ kHz}$ , $V_{BIAS} = 3\text{ V}$		65	dB
			$f = 1\text{ MHz}$ , $V_{BIAS} = 3\text{ V}$		60	dB
			$f = 1\text{ kHz}$		65	dB
			$f = 1\text{ MHz}$		60	dB

(1) External resistor tolerances are not included.

(2) The device is not tested under conditions where  $V_{IN} > V_{OUT} + 1.7\text{ V}$  and  $I_{OUT} = 3\text{ A}$ , because the power dissipation is higher than the maximum rating of the package.



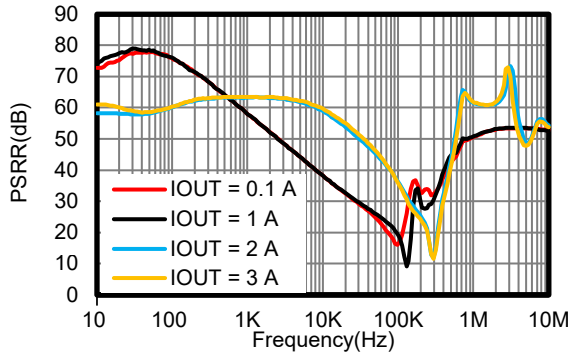
**3-A Output, High-PSRR, Low-Noise LDO Regulator**
**Electrical Characteristics (Continued)**

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;  $V_{BIAS} = \text{open}$ ,  $V_{OUT(NOM)} = 0.5\text{ V}$ ,  $V_{EN} = 1.1\text{ V}$ ,  $C_{IN} = 10\ \mu\text{F}$ ,  $C_{OUT} = 10\ \mu\text{F}$ ,  $C_{NR/SS} = 0\text{ nF}$ ,  $C_{FF} = \text{open}$ , OUT connect to  $50\ \Omega$  to ground, PG connected to  $100\ \text{k}\Omega$  to OUT, unless otherwise noted.

Parameter	Conditions	Min	Typ	Max	Unit	
<b>PSRR and Noise</b>						
$V_N$	Output Noise Voltage	BW = 10 Hz to 100 kHz, $V_{IN} = 1.1\text{ V}$ , $V_{OUT} = 0.5\text{ V}$ , $V_{BIAS} = 5\text{ V}$ , $I_{OUT} = 3\text{ A}$ , $C_{NR/SS} = 100\text{ nF}$ , $C_{FF} = 10\text{ nF}$ , $C_{OUT} = 47\ \mu\text{F} \parallel 10\ \mu\text{F} \parallel 10\ \mu\text{F}$			4	$\mu\text{V}_{\text{RMS}}$
		BW = 10 Hz to 100 kHz, $V_{OUT} = 5\text{ V}$ , $I_{OUT} = 3\text{ A}$ , $C_{NR/SS} = 100\text{ nF}$ , $C_{FF} = 100\text{ nF}$ , $C_{OUT} = 47\ \mu\text{F} \parallel 10\ \mu\text{F} \parallel 10\ \mu\text{F}$			8	$\mu\text{V}_{\text{RMS}}$
		BW = 10 Hz to 100 kHz, $V_{OUT} = 5\text{ V}$ , $I_{OUT} = 3\text{ A}$ , $C_{NR/SS} = 100\text{ nF}$ , $C_{FF} = 10\text{ nF}$ , $C_{OUT} = 47\ \mu\text{F} \parallel 10\ \mu\text{F} \parallel 10\ \mu\text{F}$			10	$\mu\text{V}_{\text{RMS}}$
<b>Temperature Range</b>						
$T_{SD}$	Thermal Shutdown	Temperature increasing			160	$^{\circ}\text{C}$
$I_{FB}$	Hysteresis				20	$^{\circ}\text{C}$

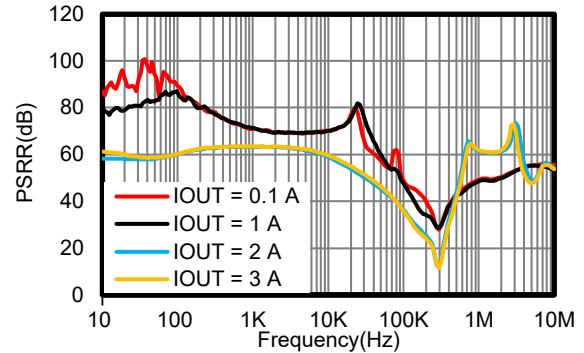
Typical Performance Characteristics

All test conditions:  $T_J = 25^\circ\text{C}$ ,  $V_{IN} = V_{OUT(NOM)} + 0.4\text{ V}$  or  $1.4\text{ V}$ , whichever is greater;  $V_{OUT(NOM)} = 0.5\text{ V}$ ,  $V_{EN} = 1.1\text{ V}$ ,  $C_{IN} = 10\text{ }\mu\text{F}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $C_{NR/SS} = 0\text{ nF}$ ,  $C_{FF} = 0\text{ nF}$ , OUT connect to  $50\text{ }\Omega$  to ground, PG connected to  $100\text{ k}\Omega$  to OUT, unless otherwise noted.



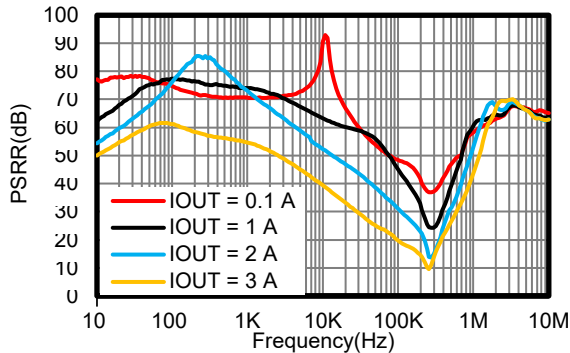
$V_{IN} = 1.4\text{ V}$ ,  $V_{OUT} = 0.5\text{ V} = 10\text{ nF}$

Figure 1. PSRR



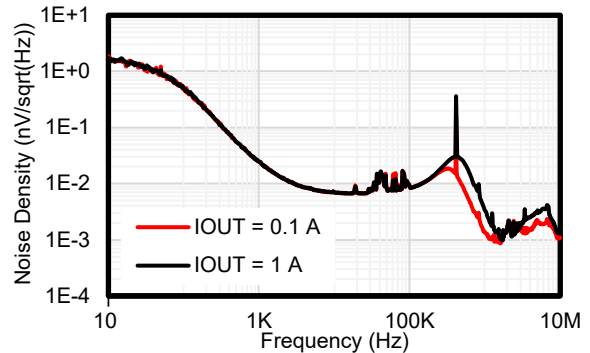
$V_{IN} = 1.1\text{ V}$ ,  $V_{BIAS} = 3\text{ V}$ ,  $V_{OUT} = 0.5\text{ V}$

Figure 2. PSRR



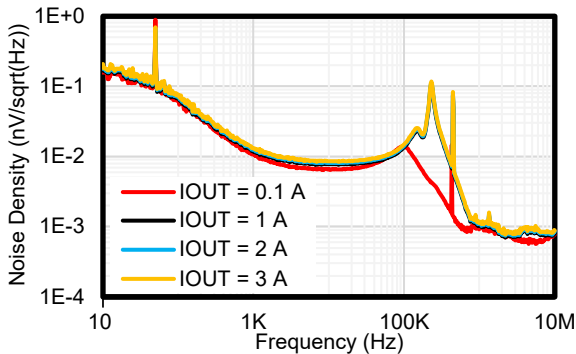
$V_{IN} = 5.5\text{ V}$ ,  $V_{OUT} = 5.2\text{ V}$ , without  $V_{BIAS}$

Figure 3. PSRR



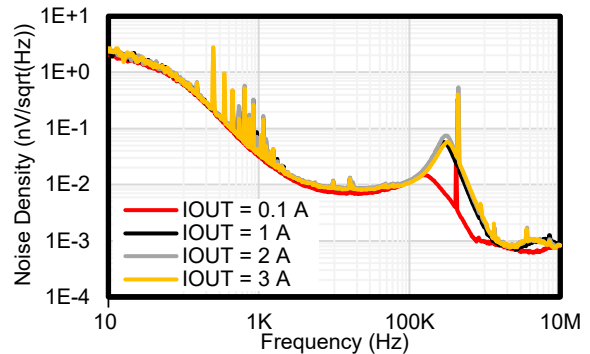
$V_{IN} = 1.1\text{ V}$ ,  $V_{OUT} = 0.5\text{ V}$

Figure 4.  $V_{BIAS}$  PSRR



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

Figure 5. Noise



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

Figure 6. Noise

3-A Output, High-PSRR, Low-Noise LDO Regulator

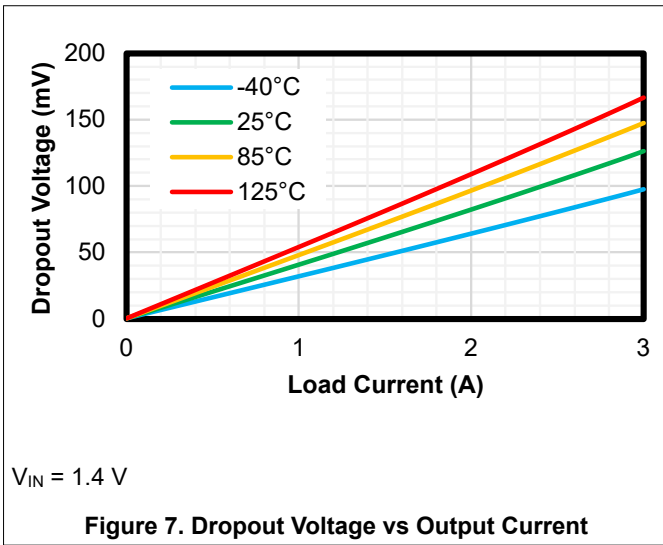


Figure 7. Dropout Voltage vs Output Current

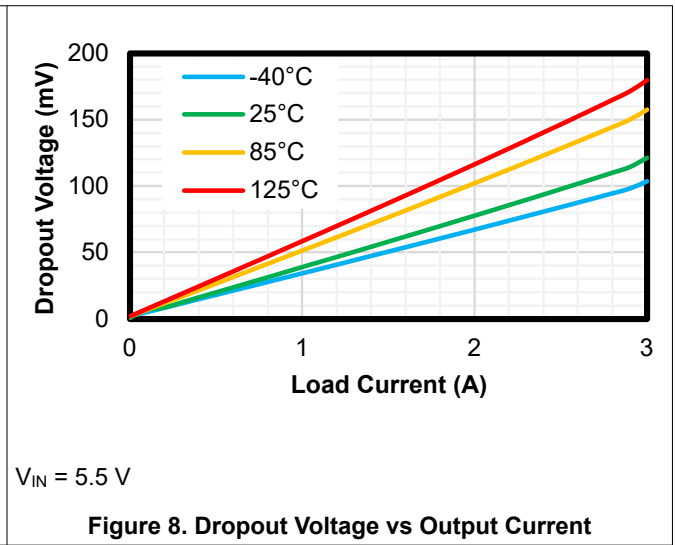


Figure 8. Dropout Voltage vs Output Current

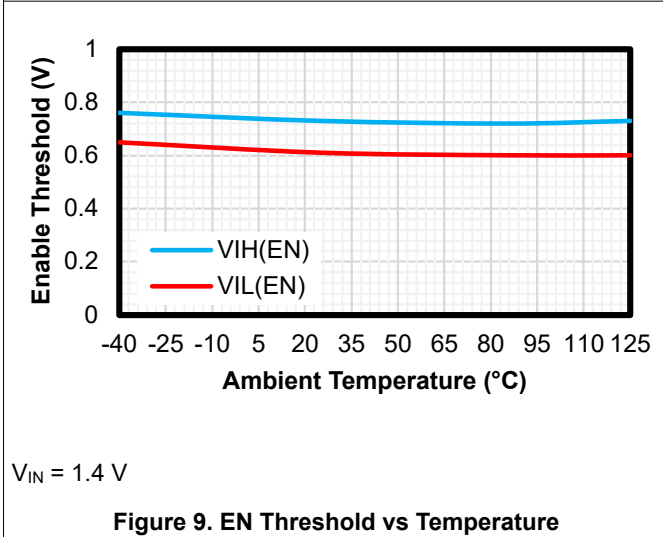


Figure 9. EN Threshold vs Temperature

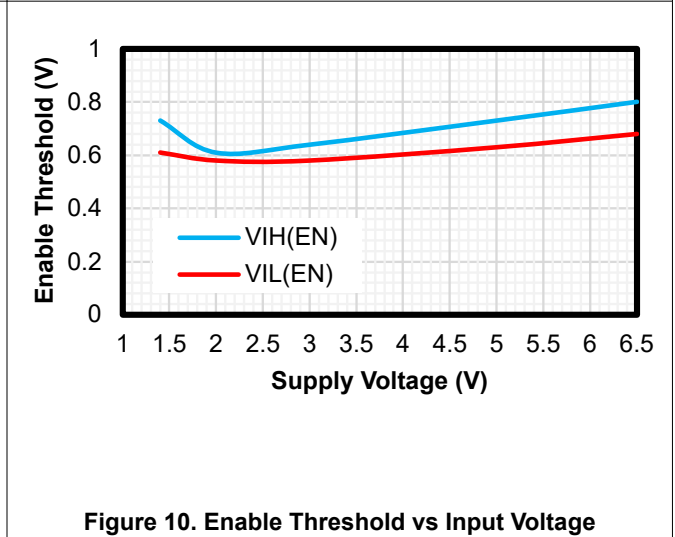


Figure 10. Enable Threshold vs Input Voltage

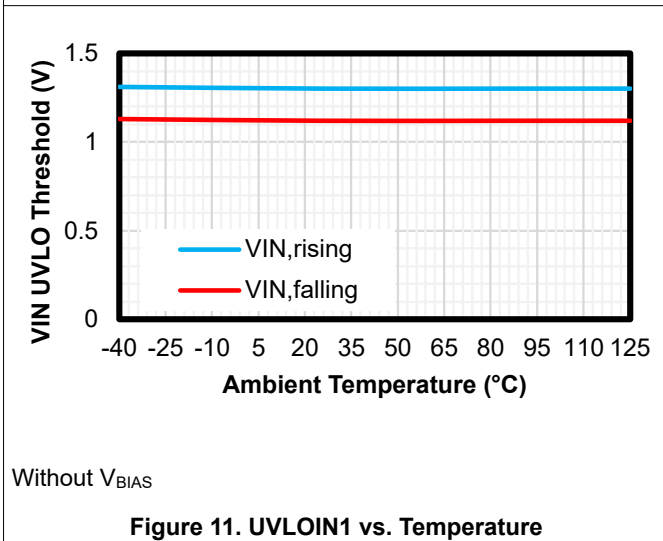


Figure 11. UVLOIN1 vs. Temperature

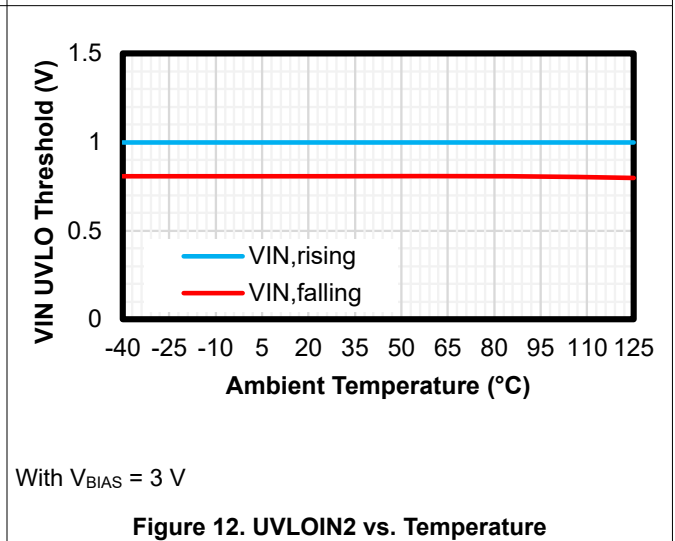
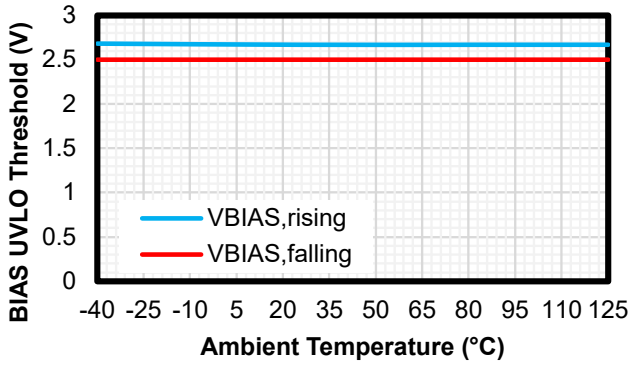
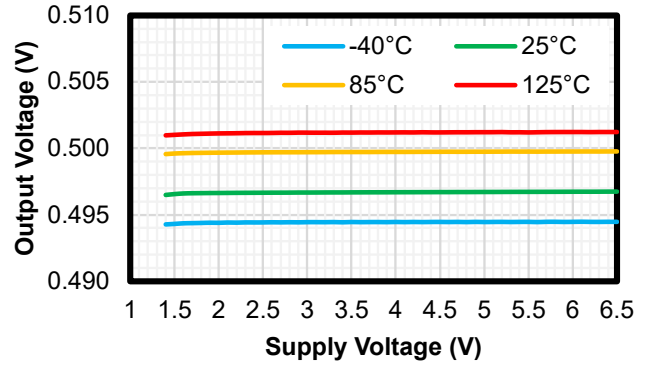


Figure 12. UVLOIN2 vs. Temperature



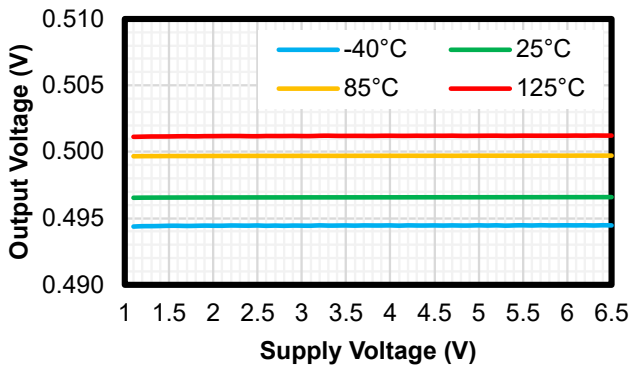
With  $V_{IN} = 1.1\text{ V}$

Figure 13. BIAS UVLO vs. Temperature



Without  $V_{BIAS}$

Figure 14. Line Regulation



With  $V_{BIAS} = 3\text{ V}$

Figure 15. Line Regulation

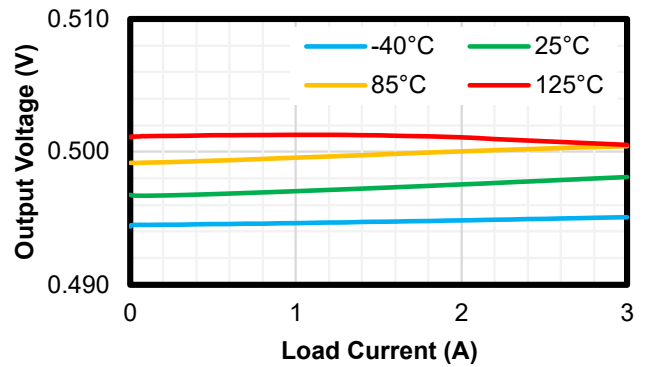
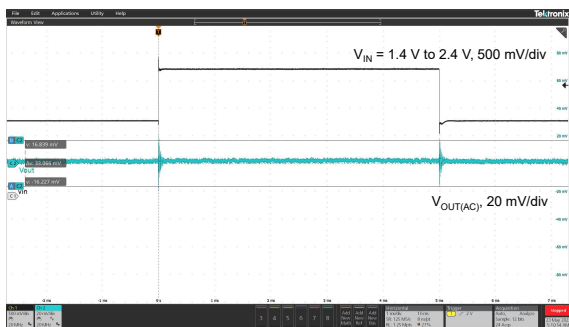
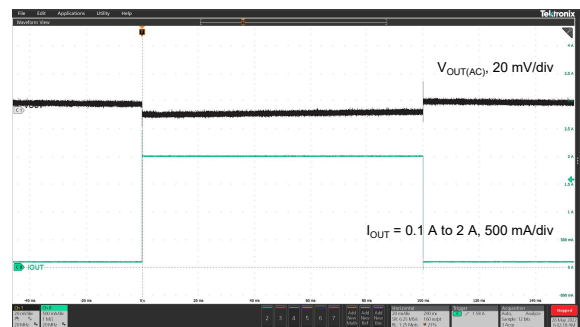


Figure 16. Load Regulation



$V_{IN} = 1.4\text{ V to } 2.4\text{ V}$ ,  $V_{OUT} = 0.5\text{ V}$ ,  $I_{OUT} = 1\text{ A}$

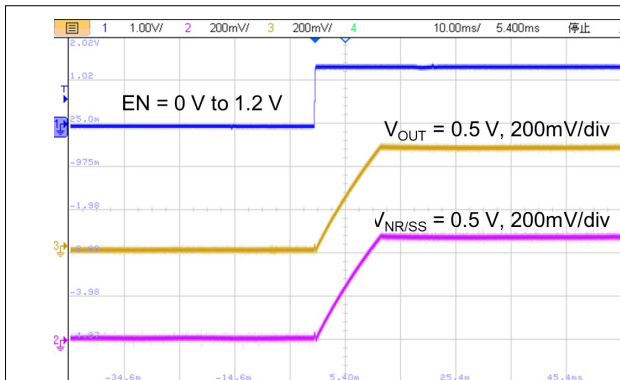
Figure 17. Line Transient



$V_{IN} = 1.4\text{ V}$ ,  $V_{OUT} = 0.5\text{ V}$ ,  $I_{OUT} = 0.1\text{ A to } 2\text{ A}$

Figure 18. Load Transient

3-A Output, High-PSRR, Low-Noise LDO Regulator



$V_{IN} = 1.4 \text{ V}, V_{OUT} = 0.5 \text{ V}, C_{NR/SS} = 100 \text{ nF}, \text{ no load}$

Figure 19. Startup

## Detailed Description

### Overview

The TPL9305 is a 3-A high-current,  $4\text{-}\mu\text{V}_{\text{RMS}}$  low-noise, high-PSRR, high-accuracy linear regulator with maximum 300-mV ultra-low dropout voltage at 3-A load condition. The TPL9305 supports both fixed output voltage ranging from 0.5 V to 3.65 V and adjustable output voltage ranging from 0.5 V to 5.2 V with an external resistor divider.

Ultra-low noise, high PSRR, and high output current capabilities make the TPL9305 an ideal power supply for noise-sensitive applications, such as high-speed communication facilities, test and measurement devices, and high-definition imaging equipment. Accurate output voltage tolerance, output voltage remote sensing, excellent transient response, and adjustable soft-start control ensure the TPL9305 an optimal power supply for the large-scale processors or digital loads, such as ASIC, FPGA, CPLD, and DSP.

### Functional Block Diagram

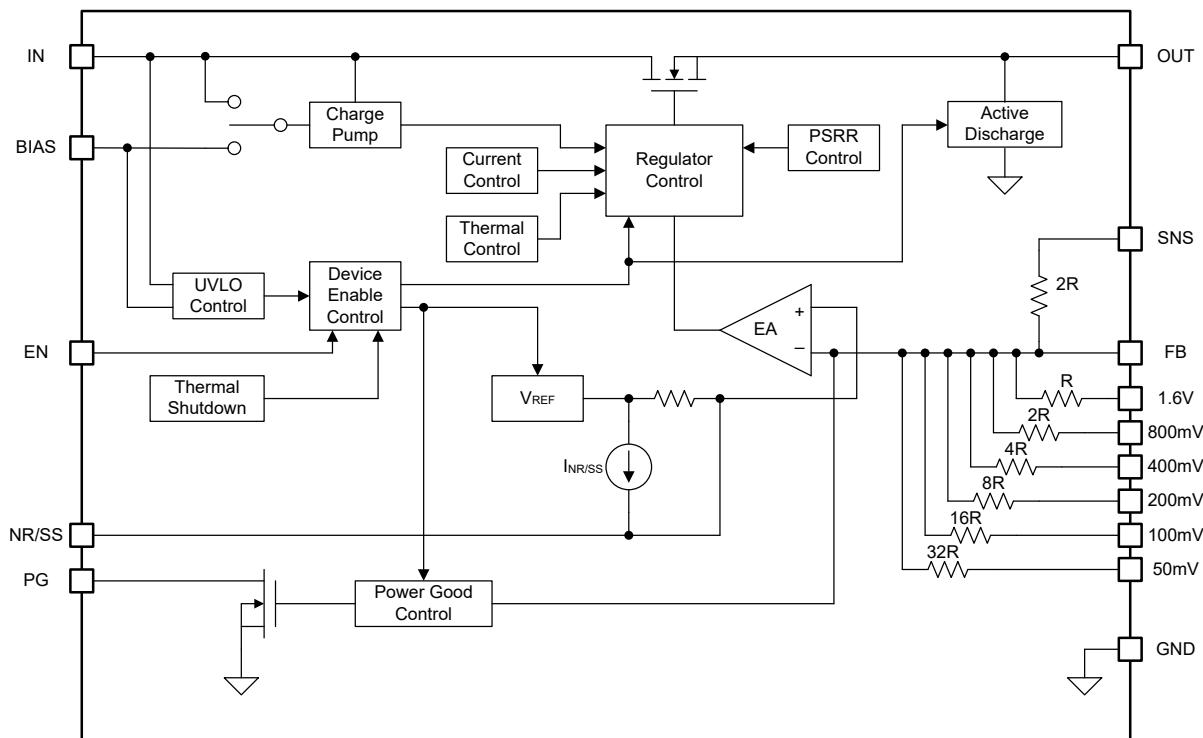


Figure 20. Functional Block Diagram

### Feature Description

#### Enable (EN)

The TPL9305 provides a device with an enable pin (EN) to enable or disable the device. Connect the enable pin to the GPIO of an external digital logic control circuit to control the device. When the  $V_{\text{EN}}$  voltage falls below  $V_{\text{IL(EN)}}$ , the LDO device turns off, and when the  $V_{\text{EN}}$  ramps above  $V_{\text{IH(EN)}}$ , the LDO device turns on.

The TPL9305 also integrates an active discharge function. During normal operation, when the enable pin is pulled down below  $V_{\text{IL(EN)}}$ , the output voltage is discharged through the internal resistive path.

**3-A Output, High-PSRR, Low-Noise LDO Regulator**
**Under-Voltage Lockout (UVLO)**

The TPL9305 uses an under-voltage lockout circuit to keep the output shut-off until the internal circuitry operates properly.

**Voltage Regulation (OUT, FB)**

The TPL9305 provides two options to set the output voltages: fixed output voltage configured by the programming pins, and adjustable output voltage configured by external resistors.

**Fixed Output Voltage Setting**

The TPL9305 integrates resistor divider internally to set the fixed output voltage. The fixed output voltage can be set from 0.5 V to 3.65 V by connecting the output voltage setting pins (pin 5 to pin 11) to ground or left them open. Use [Equation 1](#) to calculate the output voltage.

$$V_{OUT} = V_{NR/SS} + V_{Pin\_Setting} \quad (1)$$

[Table 2](#) provides a full list of different output voltage targets and the corresponding pin settings.

**Table 2. Fixed Output Voltage Setting**

V <sub>OUT</sub> (V)	50 mV	100 mV	200 mV	400 mV	800 mV	1.6 V	V <sub>OUT</sub> (V)	50 mV	100 mV	200 mV	400 mV	800 mV	1.6 V
Pin	5	6	7	9	10	11	Pin	5	6	7	9	10	11
0.5	Open	Open	Open	Open	Open	Open	2.1	Open	Open	Open	Open	Open	GND
0.55	GND	Open	Open	Open	Open	Open	2.15	GND	Open	Open	Open	Open	GND
0.6	Open	GND	Open	Open	Open	Open	2.2	Open	GND	Open	Open	Open	GND
0.65	GND	GND	Open	Open	Open	Open	2.25	GND	GND	Open	Open	Open	GND
0.7	Open	Open	GND	Open	Open	Open	2.3	Open	Open	GND	Open	Open	GND
0.75	GND	Open	GND	Open	Open	Open	2.35	GND	Open	GND	Open	Open	GND
0.8	Open	GND	GND	Open	Open	Open	2.4	Open	GND	GND	Open	Open	GND
0.85	GND	GND	GND	Open	Open	Open	2.45	GND	GND	GND	Open	Open	GND
0.9	Open	Open	Open	GND	Open	Open	2.5	Open	Open	Open	GND	Open	GND
0.95	GND	Open	Open	GND	Open	Open	2.55	GND	Open	Open	GND	Open	GND
1	Open	GND	Open	GND	Open	Open	2.6	Open	GND	Open	GND	Open	GND
1.05	GND	GND	Open	GND	Open	Open	2.65	GND	GND	Open	GND	Open	GND
1.1	Open	Open	GND	GND	Open	Open	2.7	Open	Open	GND	GND	Open	GND
1.15	GND	Open	GND	GND	Open	Open	2.75	GND	Open	GND	GND	Open	GND
1.2	Open	GND	GND	GND	Open	Open	2.8	Open	GND	GND	GND	Open	GND
1.25	GND	GND	GND	GND	Open	Open	2.85	GND	GND	GND	GND	Open	GND
1.3	Open	Open	Open	Open	GND	Open	2.9	Open	Open	Open	Open	GND	GND
1.35	GND	Open	Open	Open	GND	Open	2.95	GND	Open	Open	Open	GND	GND
1.4	Open	GND	Open	Open	GND	Open	3	Open	GND	Open	Open	GND	GND
1.45	GND	GND	Open	Open	GND	Open	3.05	GND	GND	Open	Open	GND	GND
1.5	Open	Open	GND	Open	GND	Open	3.1	Open	Open	GND	Open	GND	GND
1.55	GND	Open	GND	Open	GND	Open	3.15	GND	Open	GND	Open	GND	GND
1.6	Open	GND	GND	Open	GND	Open	3.2	Open	GND	GND	Open	GND	GND

**3-A Output, High-PSRR, Low-Noise LDO Regulator**

1.65	GND	GND	GND	Open	GND	Open	3.25	GND	GND	GND	Open	GND	GND
1.7	Open	Open	Open	GND	GND	Open	3.3	Open	Open	Open	GND	GND	GND
1.75	GND	Open	Open	GND	GND	Open	3.35	GND	Open	Open	GND	GND	GND
1.8	Open	GND	Open	GND	GND	Open	3.4	Open	GND	Open	GND	GND	GND
1.85	GND	GND	Open	GND	GND	Open	3.45	GND	GND	Open	GND	GND	GND
1.9	Open	Open	GND	GND	GND	Open	3.5	Open	Open	GND	GND	GND	GND
1.95	GND	Open	GND	GND	GND	Open	3.55	GND	Open	GND	GND	GND	GND
2	Open	GND	GND	GND	GND	Open	3.6	Open	GND	GND	GND	GND	GND
2.05	GND	GND	GND	GND	GND	Open	3.65	GND	GND	GND	GND	GND	GND

**Table 3. External Resistor Combinations**

Target Output Voltage (V)	External Resistors Divider		Calculated Output Voltage (V)
	R1 (k $\Omega$ )	R2 (k $\Omega$ )	
0.50	0	Open	0.500
0.55	12.4	124	0.550
0.60	12.4	62	0.600
0.65	12.4	41.2	0.650
0.70	12.4	31	0.700
0.75	12.4	24.8	0.750
0.80	12.4	20.5	0.802
0.85	12.4	17.8	0.848
0.90	12.4	15.4	0.903
0.95	12	13.3	0.951
1.00	12.4	12.4	1.000
1.10	12	10	1.100
1.20	12.4	8.87	1.199
1.50	12.4	6.2	1.500
1.80	12.4	4.77	1.800
2.00	12.4	4.12	2.005
2.10	12	3.74	2.104
2.50	12.4	3.1	2.500
3.00	12	2.4	3.000
3.30	12.4	2.21	3.305
3.60	12.4	2	3.600
4.50	12.4	1.55	4.500
5.00	12.4	1.38	4.993
5.20	12.7	1.35	5.204



## 3-A Output, High-PSRR, Low-Noise LDO Regulator

### Adjustable Output Voltage Setting

The TPL9305 also provides an adjustable output voltage option. Using external resistors divider, the output voltage of TPL9305 is determined by the value of the resistor R1 and R2 in [Figure 21](#). Use the [Equation 2](#) to calculate the output voltage.

$$V_{OUT} = V_{FB} \times \left(1 + \frac{R1}{R2}\right) \quad (2)$$

Where,

- the feedback voltage  $V_{FB}$  is 0.5 V
- R1 is the high-side feedback resistor
- R2 is the low-side feedback resistor

[Table 3](#) provides a list of recommended resistor combinations to achieve the common output voltage values.

### Output Soft-Start Control (NR/SS)

The TPL9305 integrates a programmable soft-start function to control the output voltage ramp-up slew rate and start-up time. By selecting the external capacitor at the NR/SS pin (CNR/SS), the output start-up time can be calculated with [Equation 3](#).

$$t_{STRATUP} = 1.25 \times \frac{V_{NR/SS} \times C_{NR/SS}}{I_{NR/SS}} \quad (3)$$

Where,

- the typical value of  $V_{NR/SS}$  is 0.5 V
- the typical value of  $I_{NR/SS}$  is 7.8  $\mu$ A
- $C_{NR/SS}$  is the external capacitor at the NR/SS pin

### Charge Pump Noise

The TPL9305 integrates a charge pump to improve the PSRR and transient response under low input voltage conditions. The charge pump circuit generates a minimal amount of noise at the frequency of around 15 MHz. It is recommended to use 10-nF to 100-nF bypass capacitors close to the load a ferrite bead between the LDO output and the load input capacitors, forming a pi-filter to reduce the high-frequency noise level.

### Power Good (PG)

The TPL9305 integrates an open-drain output power good indicator. Connect the PG pin to a pull-up voltage through a resistor from 10 k $\Omega$  to 100 k $\Omega$  if the power good function is used. Left the PG pin open if it is not used.

After regulator startup, the PG pin keeps low impedance until the output voltage reaches the power good threshold  $V_{PG,TH}$ . When the output voltage is higher than  $V_{PG,TH}$ , the PG pin turns to high output impedance, and PG is pulled up to a high voltage level to indicate the output voltage is ready

### Output Active Discharge

The TPL9305 integrates an output discharge path from OUT to GND. When the device is disabled, the output will actively discharge the output voltage through an internal resistor of several hundred ohms.

Do not rely on this active discharge circuit for discharging large output capacitors when the input voltage falls below the output voltage. Reverse current flow through internal power MOSFET can permanently damage the device, and external current protection is essential at this condition.

**Over-Current Protection and Short-to-Ground Protection**

The TPL9305 series integrates an internal current limit that helps to protect the device during fault conditions. When the output is pulled down below the target output voltage, over-current protection starts to work and limit the output current to a typical value of 4.7 A.

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

**Over-Temperature Protection**

The recommended operating junction temperature range is from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . When the junction temperature is between  $125^{\circ}\text{C}$  and the thermal shutdown (TSD) threshold, the regulator can still work well, but will reduce the device lifetime for long-term use.

The over-temperature protection works when the junction temperature exceeds the thermal shutdown (TSD) threshold, which turns off the regulator immediately. 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.

## 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 TPL9305 is a 3-A high-current, low-noise, high-PSRR, high-accuracy linear regulator with a maximum 300-mV ultra-low dropout voltage at 3-A load condition. The following application schematic shows the typical usage of the TPL9305.

## Typical Application

### Adjustable Output Operation

Figure 21 shows a typical application schematic of the TPL9305 with adjustable output operation. Refer to section [Adjustable Output Voltage Setting](#) to set the output voltage.

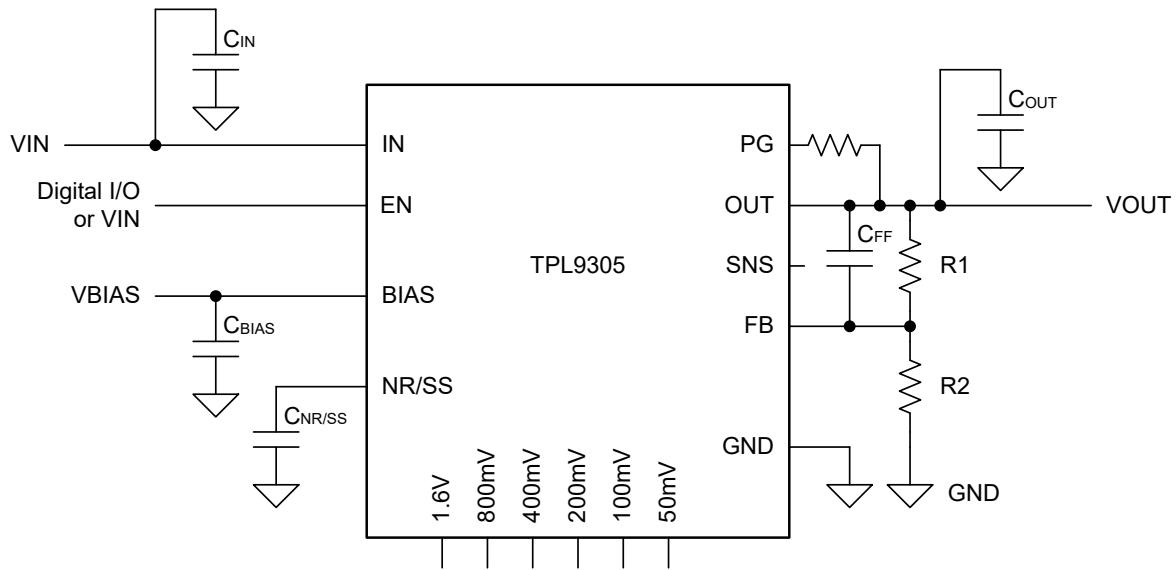


Figure 21. Adjustable Output Operation

### Fixed Output Operation

Figure 22 shows a typical application schematic of the TPL9305 with fixed output operation. Refer to the section [Fixed Output Voltage Setting](#) to set the output voltage. In this example, output voltage is set to 1.5 V ( $V_{NR/SS} + 0.8\text{ V} + 0.2\text{ V}$ ).

3-A Output, High-PSRR, Low-Noise LDO Regulator

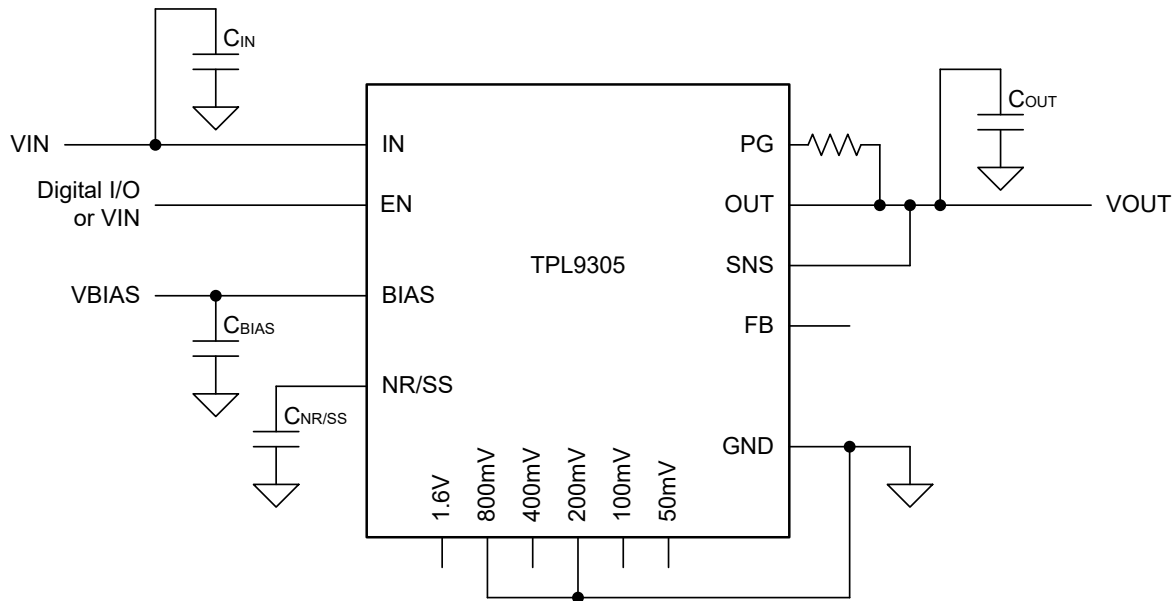


Figure 22. Fixed 1.5-V Output Voltage Operation

**Input Capacitor and Output Capacitor**

The TPL9305 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 ranges.

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 TPL9305 requires an output capacitor with a minimum effective capacitance value of 10  $\mu$ F. 3PEAK recommends selecting an X7R-type 22- $\mu$ 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 not exceed 125°C. Using below equations to calculate the power dissipation and estimate the junction temperature.

The power dissipation can be calculated using [Equation 4](#).

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_{GND} \tag{4}$$

The junction temperature can be estimated using [Equation 5](#).  $\theta_{JA}$  is the junction-to-ambient thermal resistance.

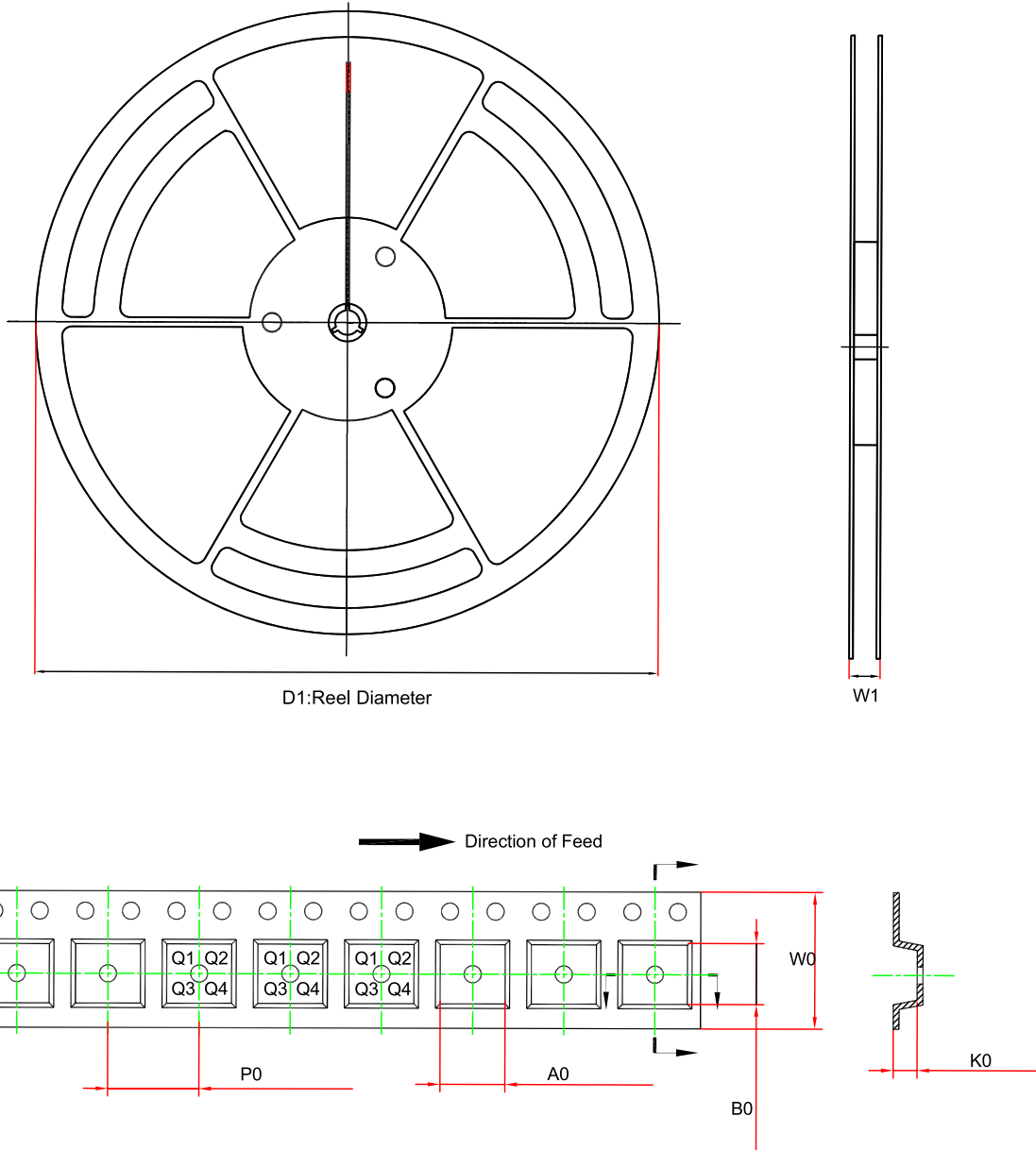
$$T_J = T_A + P_D \times \theta_{JA} \tag{5}$$

## Layout

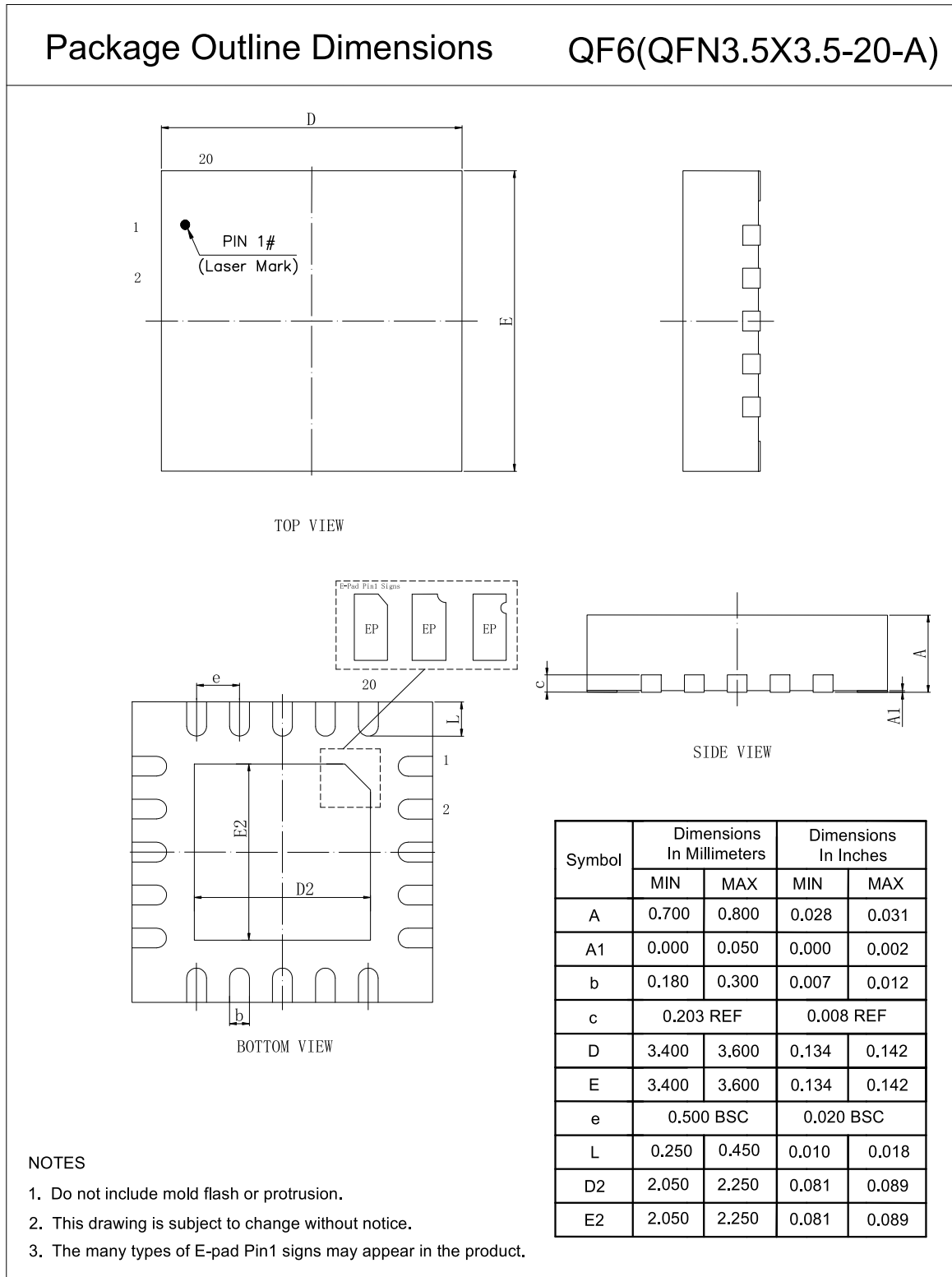
### Layout Guideline

- 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×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
TPL9305AD-QF6R-S	QFN3.5X3.5-20	330	17.6	3.8	3.8	1.1	8	12	Q2

**Package Outline Dimensions**
**QFN3.5X3.5-20**


**Order Information**

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPL9305AD-QF6R-S	-40°C to +125°C	QFN3.5X3.5-20	L935A	MSL3	Tape and Reel, 4,000	Green

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



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