

### Features

- Input Voltage Range: 1.7 V to 5.5 V
- Output Voltage Range: 0.6 V to 5.3 V
- $\pm 1.5\%$  Output Accuracy Over Line Regulation, Load Regulation, and Operating Temperature Range
- 500 mA Maximum Output Current
- Low Dropout Voltage: 150 mV Typical at 500 mA
- High PSRR:
  - ◆ 89 dB at 1kHz
  - ◆ 63 dB at 100kHz
  - ◆ 55 dB at 1MHz
- 5.7  $\mu\text{V}_{\text{RMS}}$  Output Voltage Noise
- Excellent Transient Response
- Stable with a 4.7  $\mu\text{F}$  or Larger Ceramic Output Capacitor
- Over-Current and Over-Temperature Protection
- Output Reverse Current Protection
- Junction Temperature Range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- Package Options: 2x2 DFN-8

### Applications

- Portable and Battery-Powered Equipment
- Mobile Phones and Tablets
- Digital Cameras and Audio Devices Power Supply
- Video Surveillance

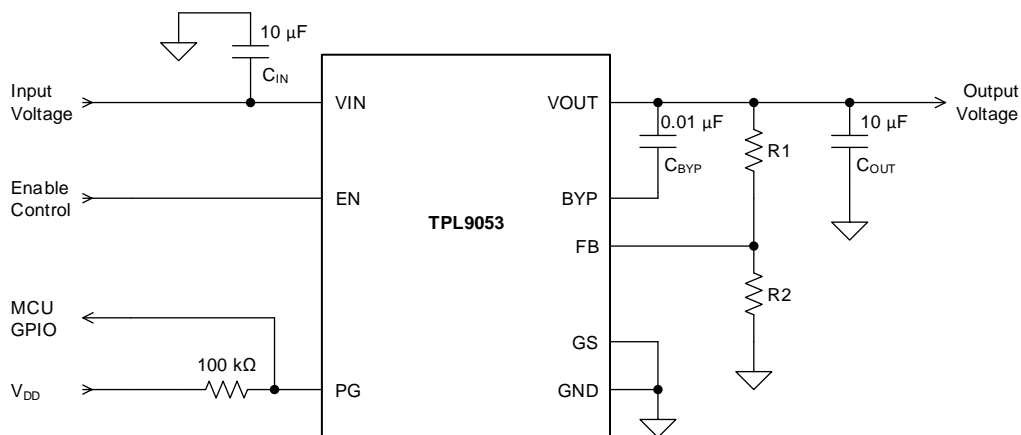
### Description

The TPL9053 series products are 500-mA high PSRR, ultra-low noise, low dropout linear regulators with high output accuracy. The TPL9053 series products support adjustable output voltage ranges from 0.6 V to 5.3 V with external resistor divider and is stable with 4.7  $\mu\text{F}$  or larger ceramic output capacitor.

The TPL9053 series products have high PSRR with 89 dB at 1kHz and 5.7  $\mu\text{V}_{\text{RMS}}$  ultra-low noise. These features make TPL9053 series products very suitable for noise-sensitive applications with high noise from previous stage power supply, such as high-performance analog devices, or high-definition imaging equipment. Output shortage protection and thermal overload protection circuits improves the reliability under heavy load conditions.

The TPL9053 series products provide 2x2 DFN-8 package with guaranteed operating junction temperature range ( $T_J$ ) from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

### Typical Application Schematic



## Product Family Table

Part Number	Orderable Number	Output Voltage	Package	Transport Media, Quantity	MSL	Marking information
TPL9053	TPL9053AD-DF4R	Adjustable	2×2 DFN-8	Tape and Reel, 3,000	MSL3	L905

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## Revision History

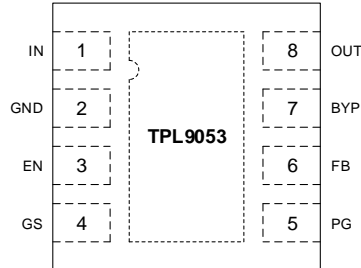
Date	Revision	Notes
2019/08/31	Rev.Pre	Preliminary Version
2020/04/08	Rev.A.0	Initial Released
2020/10/18	Rev.A.1	Add more details to PG pin description (Page 5) and PG function description (Page 12)

### Pin Configuration and Functions

#### TPL9053 Series

8-Pin 2×2 DFN

Top View



### Pin Functions

NAME	PIN NUMBER	TYPE	DESCRIPTION
BYP	7	I	Bypass input pin. Connect a 10-nF ceramic capacitor from BYP to OUT to reduce output noise.
EN	3	I	Regulator enable pin. Drive EN high to turn on the regulator; and drive EN low to turn off the regulator. For automatic startup, connect EN to IN directly.
FB	6	I	Output voltage feedback pin. Connect to a resistor divider to adjust the output voltage.
GND	2	–	Ground reference pin. Connect GND pin to PCB ground plane directly.
GS	4	–	Internal reference pin. MUST connect GS pin to PCB ground plane directly.
IN	1	I	Input voltage pin. Bypass IN to GND with a 10 $\mu$ F or greater capacitor.
OUT	8	O	Regulated output voltage pin. Bypass OUT to GND with a 4.7 $\mu$ F or greater capacitor.
PG	5	O	Open-drain power-good output pin. Connect a 100-k $\Omega$ pull-up resistor to the logic voltage supply, or leave this pin open if not used. PG goes <b>LOW</b> after the output voltage ramps above $V_{PG,TH}$ , and PG keeps <b>HIGH</b> when the output voltage is below the threshold.

(1) Thermal Pad MUST be connected to PCB ground plane directly.

## Specifications

### Absolute Maximum Ratings

		MIN	MAX	UNIT
EN, IN		-0.3	6	V
BYP, FB, GS, OUT, PG		-0.3	6	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 the Absolute Maximum Ratings may permanently damage the device.

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

### ESD Ratings

		Condition	Minimum Level	UNIT
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001	±6000	V
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002	±1500	V

### Recommended Operating Conditions

		MIN	MAX	UNIT
IN		1.7	5.5	V
EN		0	V <sub>IN</sub>	V
OUT		0	5.5	V
BYP, FB, PG		0	V <sub>OUT</sub>	V
C <sub>BYP</sub>		1	100	nF
C <sub>OUT</sub>		4.7		μF
ESR		1	100	mΩ
T <sub>J</sub>	Junction Temperature Range	-40	125	°C
P <sub>D</sub>	Power Dissipation	0	400	mW

### Thermal Information

PACKAGE	θ <sub>JA</sub>	θ <sub>JC</sub>	UNIT
2×2 DFN-8	120	20.3	°C/W

## Electrical Characteristics

All test condition:  $V_{IN} = V_{OUT(NOM)} + 1V$ ,  $C_{IN} = 10 \mu F$ ,  $C_{OUT} = 10 \mu F$ ,  $-40^{\circ}C \leq T_J \leq +125^{\circ}C$ , unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>Supply Input Voltage and Current</b>						
$V_{IN}$	Input supply voltage range		1.7		5.5	V
$I_{GND}$	Ground pin current	$I_{OUT} = 0 \text{ mA}$		130	180	$\mu A$
$I_{SHDN}$	Shutdown current	EN = GND		0.05	2	$\mu A$
<b>Enable Input Voltage and Current</b>						
$V_{IN(EN)}$	EN logic-input high level (enable)		1.2		$V_{IN}$	V
$V_{IL(EN)}$	EN logic-input low level (disable)		0		0.4	V
$I_{EN}$	EN pin leakage current	$V_{EN} = 5 \text{ V}$		1	2	$\mu A$
<b>Regulated Output Voltage and Current</b>						
$V_{OUT}$	Output voltage accuracy	$-40^{\circ}C \leq T_J \leq +125^{\circ}C$	-1.5%		1.5%	
$\Delta V_{OUT}$	Line regulation	$V_{IN} = V_{OUT(NOM)} + 1 \text{ V to } 5.5 \text{ V}$		1		mV/V
	Load regulation	$V_{IN} = V_{OUT(NOM)} + 1 \text{ V}$ , $I_{OUT} = 1 \text{ mA to } 500 \text{ mA}$		0.005		mV/mA
$V_{DO}^{(1)}$	Dropout voltage	$V_{IN} \geq 3.6 \text{ V}$ , $I_{OUT} = 100 \text{ mA}$		30	60	mV
		$V_{IN} \geq 3.6 \text{ V}$ , $I_{OUT} = 500 \text{ mA}$		150	280	mV
		$V_{IN} = 1.7 \text{ V}$ , $I_{OUT} = 500 \text{ mA}$		300		mV
$I_{OUT}$	Output voltage	$V_{OUT}$ in regulation	0		500	mA
$I_{LIM}$	Output current limit	$V_{OUT} = 0.9 \times V_{OUT(NOM)}$	550	720		mA
$I_{SC}$	Short-circuit to ground current limit	$V_{OUT}$ is forced to $\leq 50 \text{ mV}$ , $T_A = 25^{\circ}C$		100		mA
PSRR	Power supply rejection ratio	$I_{OUT} = 20 \text{ mA}$ , $f = 100 \text{ Hz}$		82		dB
		$I_{OUT} = 20 \text{ mA}$ , $f = 1 \text{ kHz}$		89		dB
		$I_{OUT} = 20 \text{ mA}$ , $f = 100 \text{ kHz}$		63		dB
		$I_{OUT} = 20 \text{ mA}$ , $f = 1 \text{ MHz}$		55		dB
$V_N$	Output noise voltage	$I_{OUT} = 150 \text{ mA}$ , BW = 100Hz to 80 kHz		5.7		$\mu V_{RMS}$
$t_{STR}$	Start-up time	$V_{OUT}$ reaches 95% of nominal output voltage after EN = high		0.8	3	ms
<b>Feedback and Bypass</b>						
$V_{FB}$	Output feedback voltage		0.591	0.6	0.609	V
$I_{FB}$	Output feedback leakage current	$V_{IN} = 5.5 \text{ V}$ , $V_{FB} = 0.75 \text{ V}$ , $T_A = 25^{\circ}C$		0.001	0.1	$\mu A$
$I_{BYP}$	BYP pin current during startup			1		mA
<b>Power Good</b>						
$V_{PG,TH}$	PG threshold	OUT rising until PG is toggled	88	91	94	% of $V_{OUT}$
	PG hysteresis			2.5		% of $V_{OUT}$
$V_{PG,IL}$	PG voltage low	1mA to PG pin		10	100	mV
$I_{PG}$	PG pin leakage current		-1	0.01	1	$\mu A$

(1) The dropout voltage is defined as  $V_{DO} = V_{IN} - V_{OUT}$ . For  $V_{IN} \geq 3.6 \text{ V}$  condition, dropout voltage is measured when the FB pin voltage is forced at 0.58 V. For  $V_{IN} = 1.7 \text{ V}$  condition, dropout voltage is guaranteed by design.

## Electrical Characteristics (continued)

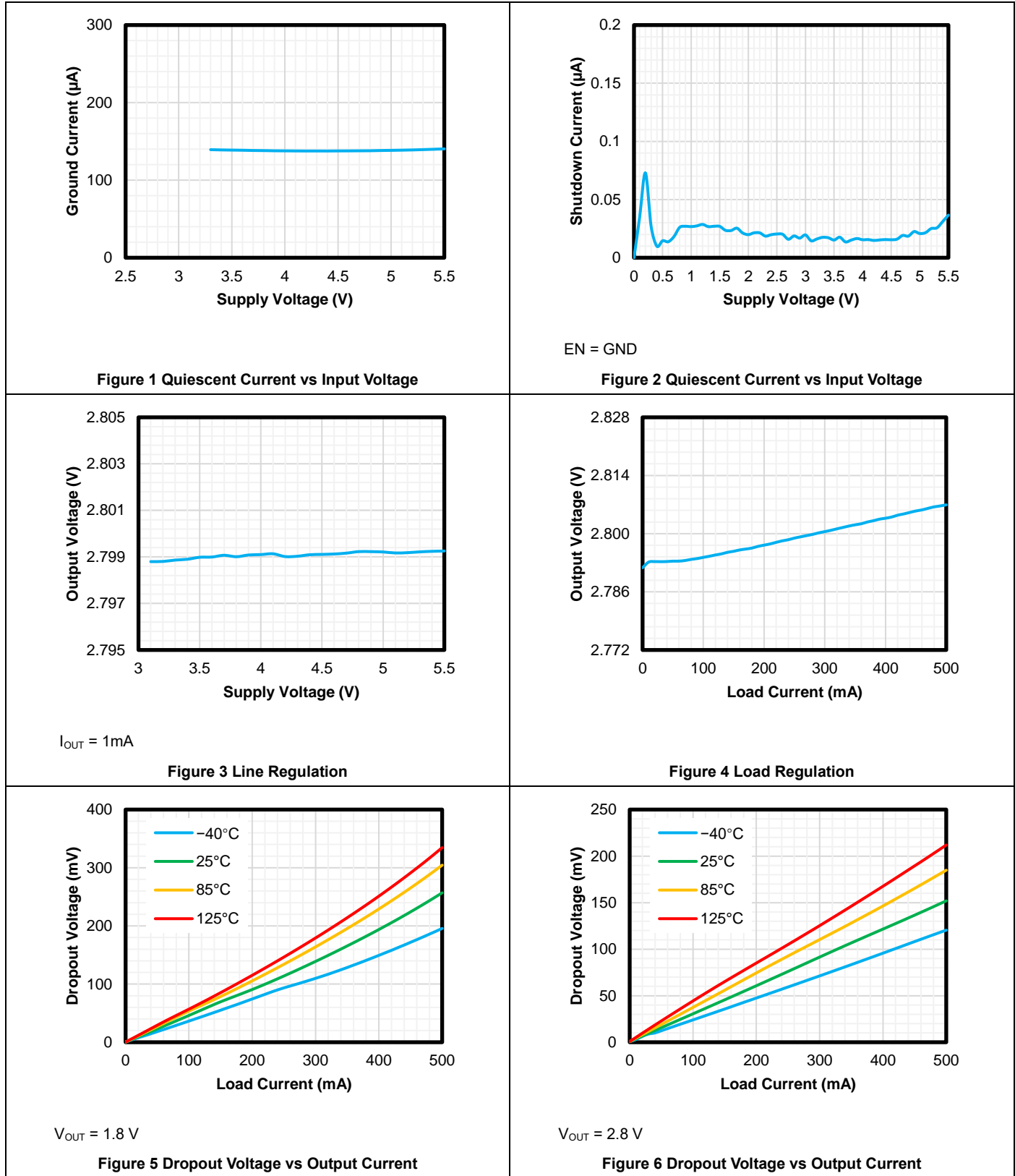
All test condition:  $V_{IN} = V_{OUT(NOM)} + 1V$ ,  $C_{IN} = 10 \mu F$ ,  $C_{OUT} = 10 \mu F$ ,  $-40^{\circ}C \leq T_J \leq +125^{\circ}C$ , unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>Transient Characteristics</b>						
$\Delta V_{OUT}$	Line Transient	$V_{IN} = 3.8 V$ to $4.8 V$ , rising and falling slew rate is $1V/5\mu s$ , $I_{OUT} = 500 mA$		3		mVpp
	Load Transient	$I_{OUT} = 2 mA$ to $100 mA$ in $1 \mu s$		10		mVpp
		$I_{OUT} = 50 mA$ to $500 mA$ in $1 \mu s$		20		mVpp
$V_{REV,TH}$	IN-OUT Reverse voltage turnoff threshold	$V_{OUT} - V_{IN}$ when input voltage falls		19		mV
<b>Temperature Range</b>						
$T_{SD}$	Thermal shutdown temperature			165		$^{\circ}C$
	Thermal shutdown hysteresis			15		$^{\circ}C$



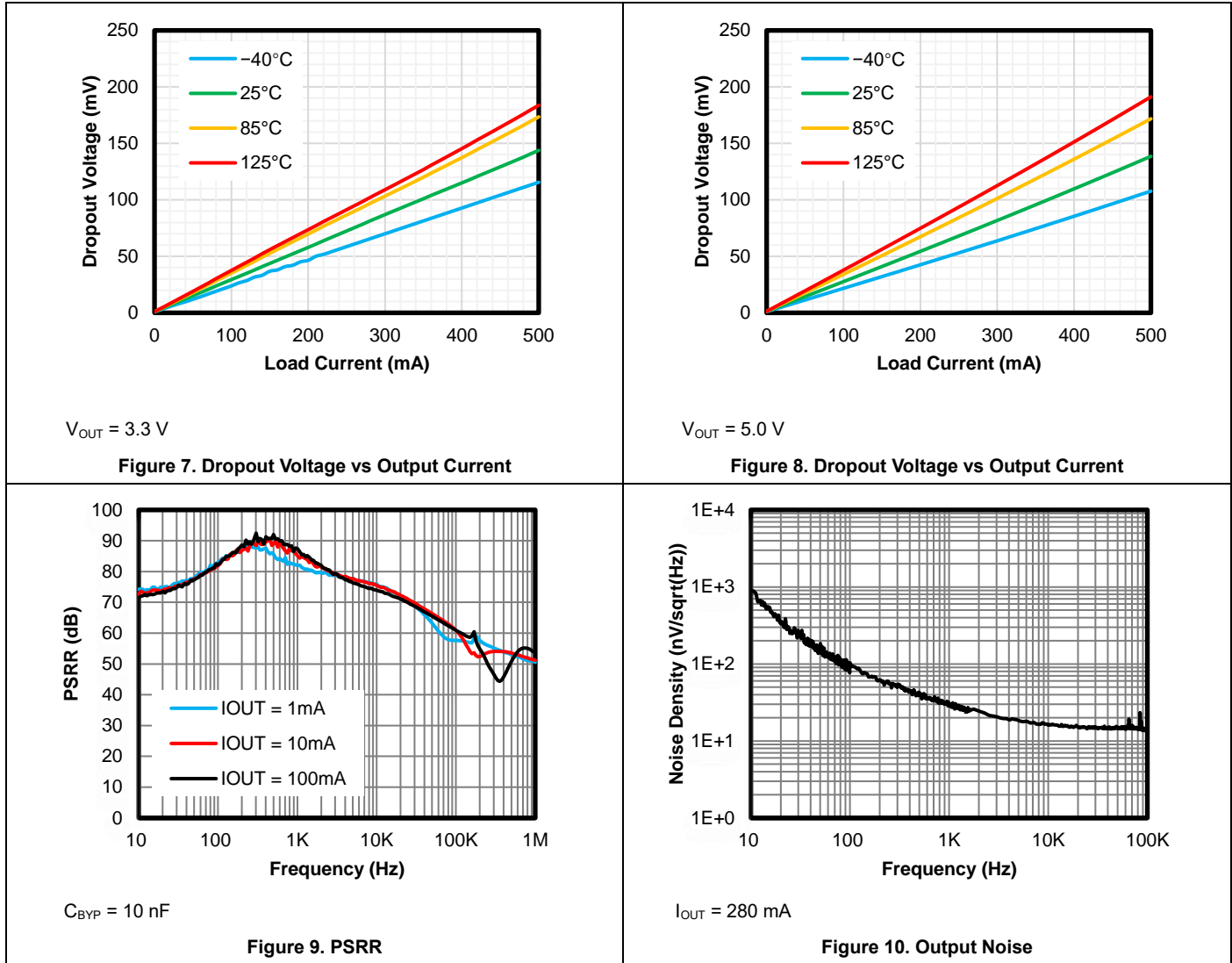
### Typical Performance Characteristics

All test condition:  $V_{IN} = V_{OUT(NOM)} + 1V$ ,  $V_{OUT} = 2.8V$ ,  $C_{IN} = 10 \mu F$ ,  $C_{OUT} = 10 \mu F$ ,  $T_J = 25^\circ C$ , unless otherwise noted.



Typical Performance Characteristics (continued)

All test condition:  $V_{IN} = V_{OUT(NOM)} + 1V$ ,  $V_{OUT} = 2.8V$ ,  $C_{IN} = 10 \mu F$ ,  $C_{OUT} = 10 \mu F$ ,  $T_J = 25^\circ C$ , unless otherwise noted.



### Detailed Description

#### Overview

The TPL9053 series products are 500-mA high PSRR, ultra-low noise, low dropout linear regulators with high output accuracy. The TPL9053 series products support adjustable output voltage ranges from 0.6 V to 5.3 V with external resistor divider and is stable with 4.7 μF or larger ceramic output capacitor.

The TPL9053 series products have high PSRR with 89 dB at 1kHz and 5.7 μVRMS ultra-low noise. These features make TPL9053 series products very suitable for noise-sensitive applications with high noise from previous stage power supply, such as high-performance analog devices, or high-definition imaging equipment. Output shortage protection and thermal overload protection circuits improves the reliability under heavy load conditions.

#### Functional Block Diagram

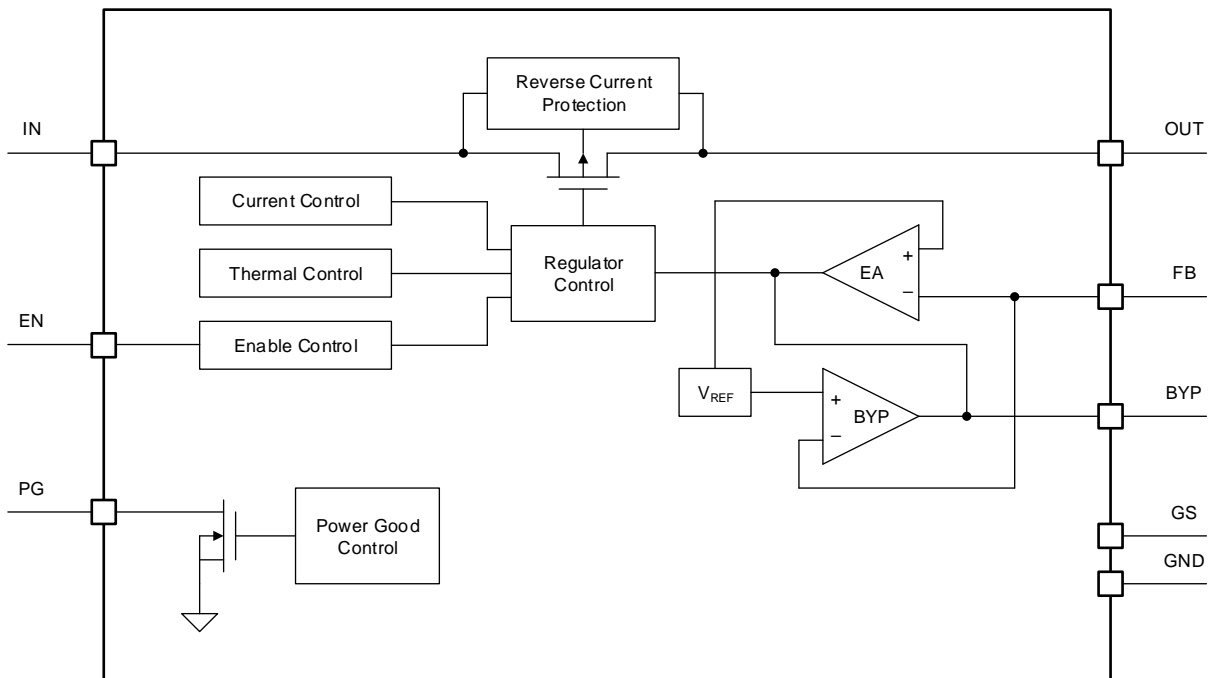


Figure 11 TPL9053 Functional Block Diagram

#### Feature Description

##### Enable (EN)

The enable pin (EN) is active high. Connect this pin to the GPIO of an external processor or digital logic control circuit to enable and disable the device. Or connect this pin to the IN pin for self-bias applications.

##### Adjustable Output Voltage (FB and OUT)

The output voltage range of TPL9053 series can be set from 0.6 V to 5.3 V by selecting different external resistors as shown in Figure 12. Use Equation 1 to calculate the output voltage. Suggest setting the resistance of lower feedback resistor R2 between 50 kΩ and 120 kΩ to minimize FB input bias current error.

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

Where the feedback voltage  $V_{FB}$  is 0.6 V.

### Output Voltage Ramp-up Slew Rate Control

To avoid the start-up inrush current, the TPL9053 series integrate an output voltage ramp-up slew rate control. When the input voltage is ready and the device-enable signal asserts, the output voltage of TPL9053 ramps up with a fixed slew rate. Under room temperature condition, it takes 800  $\mu\text{s}$  from the rising edge of enable signal to the  $V_{\text{OUT}}$  reaching 95% of nominal output voltage. This start-up time is independent with output capacitor and BYP capacitor, and the maximum 3-ms start-up time occurs under the  $-40^{\circ}\text{C}$  ambient temperature condition.

### Bypass (BYP)

The TPL9053 series provide the BYP pin to reduce the regulator output noise and offer a feed-back path to improve the transient response. Suggest connecting a capacitor from 1nF to 100nF from BYP to OUT.

### Power-Good Indicator (PG)

The TPL9053 series integrate an open-drain output power good indicator. After regulator startup, the PG pin keeps high impedance until the output voltage reached the power good threshold  $V_{\text{PG,TH}}$  (91% of  $V_{\text{OUT}}$ ). When output voltage is higher than  $V_{\text{PG,TH}}$ , the PG pin turns to low output impedance, and PG is pulled down to low voltage level to indicate the output voltage is ready.

Figure 12 shows the power good indicator status after device starts up.

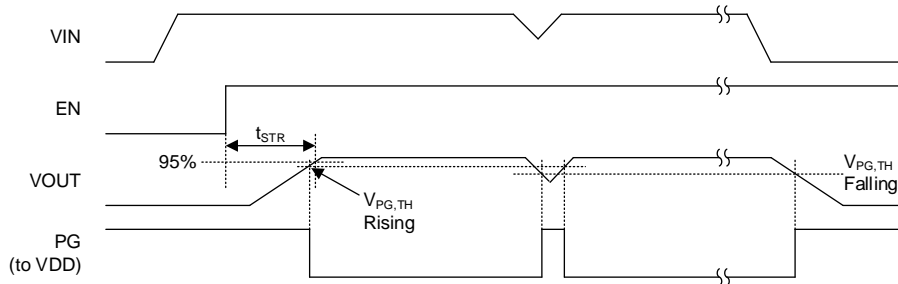


Figure 12 Power Good Indication

### Reverse-Current Protection

The TPL9053 series provide the RCP protection to prevent output reverse current. If large capacitors been used at the output, there would be large reverse current when the input voltage is lower than output voltage. The TPL9053 series can shut off the regulator and body diode path to prevent the device damaged from reverse current fault.

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

The TPL9053 series integrate an internal current limit that helps to protect the regulator during fault conditions.

- When the output is pulled down below the regulated voltage, over-current protection starts to work and limit the output current to 720 mA (typ).
- When the output is shorted to ground directly or pulled down below 50 mV, short-to-ground protection starts to work and limit the output current to 100 mA (typ).

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 recommended operating junction temperature range is  $-40^{\circ}\text{C}$  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 using.

The over-temperature protection works 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 thermal shutdown threshold minus thermal shutdown hysteresis, the regulator turns on again.

### Application and Implementation

#### NOTE

Information in the following applications 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 TPL9053 devices are a series of 500-mA high PSRR, ultra-low noise, low-dropout linear regulator. The following application schematic shows a typical usage of the TPL9053 series.

### Typical Application

Figure 13 shows the typical application schematic of the TPL9053 series.

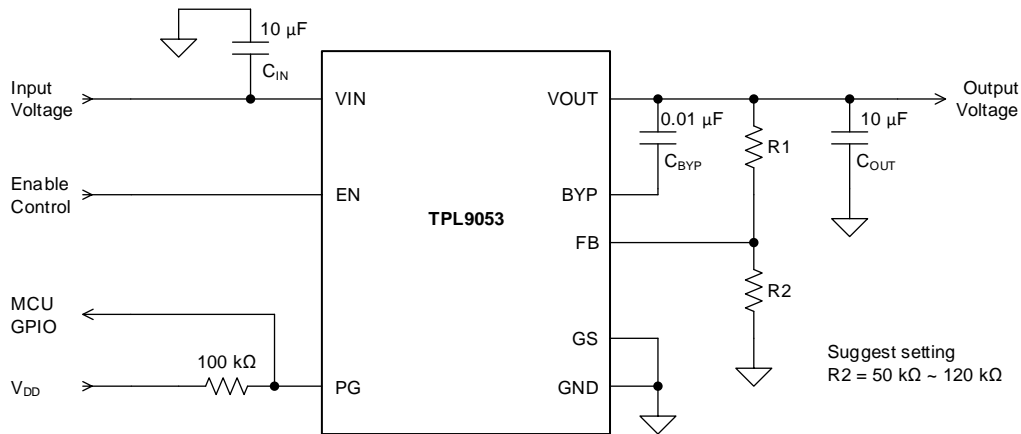


Figure 13 Typical Application Schematic

### Input Capacitor and Output Capacitor

3PEAK recommends adding a 10 µF or greater capacitor with a 0.1 µF bypass capacitor in parallel at 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 TPL9053 series requires an output capacitor of 4.7 µF or greater. 3PEAK recommends selecting a X5R- or X7R-type 10-µF 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 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.

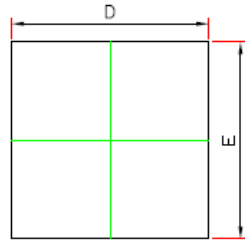
$$T_J = T_A + P_D \times \theta_{JA} \quad (3)$$

## Layout Requirements

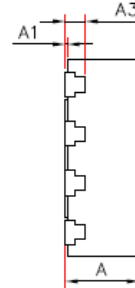
- Both input capacitors and output capacitors must be placed as close to the device pins as possible.
- It is recommended to bypass the input pin to ground with a 0.1  $\mu\text{F}$  bypass capacitor. The loop area formed by the bypass capacitor connection, IN pin and the GND pin of the system must be as small as possible.
- It is recommended to use wide trace lengths or thick copper weight to minimize  $I \times R$  drop and heat dissipation.

**Package Outline Dimensions**

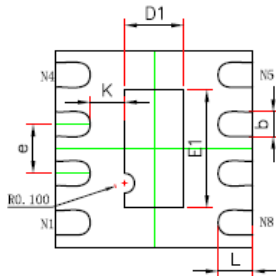
**2x2 DFN-8**



TOP VIEW



SIDE VIEW



BOTTOM VIEW

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	1.900	2.100	0.075	0.083
E	1.900	2.100	0.075	0.083
D1	0.500	0.700	0.020	0.028
E1	1.100	1.300	0.043	0.051
k	0.350REF.		0.014REF.	
b	0.200	0.300	0.008	0.012
e	0.500BSC.		0.020BSC.	
L	0.274	0.426	0.011	0.017

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