

## 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 1 kHz
  - 63 dB at 100 kHz
  - 55 dB at 1 MHz
- 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: DFN2X2-8

## Applications

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

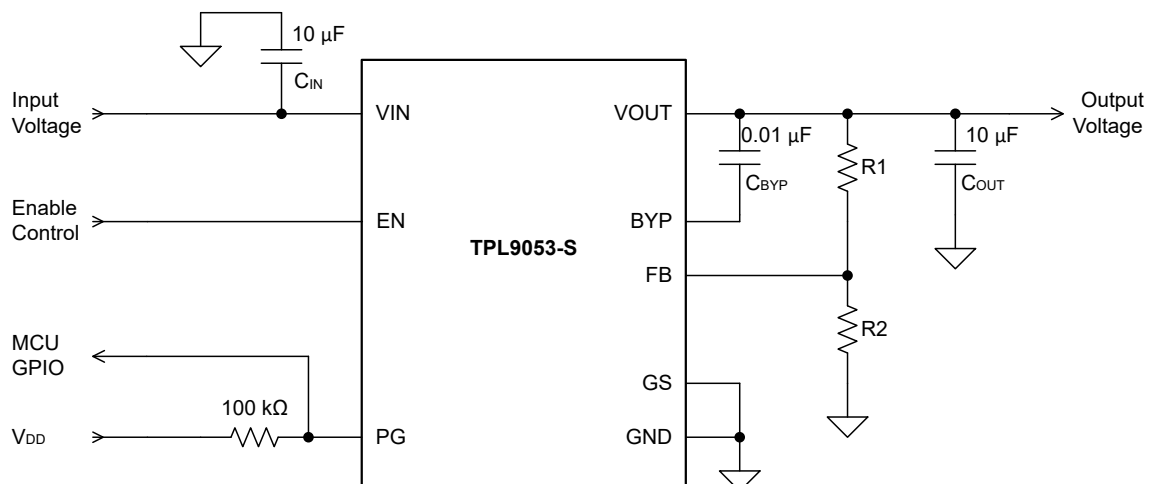
## Description

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

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

The TPL9053-S series products provide a DFN2X2-8 package with guaranteed operating junction temperature range ( $T_J$ ) 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> |
| DFN2X2-8.....                                 | 17        |
| <b>Order Information</b> .....                | <b>18</b> |
| <b>IMPORTANT NOTICE AND DISCLAIMER</b> .....  | <b>19</b> |

## Product Family Table

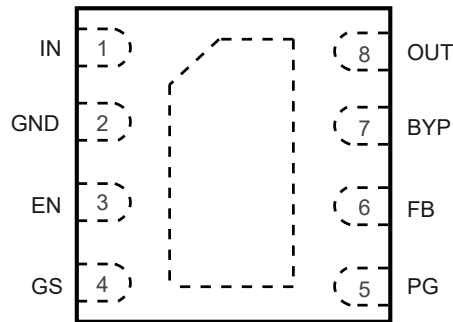
| Order Number     | Output Voltage (V) | Package  |
|------------------|--------------------|----------|
| TPL9053AD-DF4R-S | Adjustable         | DFN2X2-8 |

## Revision History

| Date       | Revision | Notes  |
|------------|----------|--|
| 2019/08/31 | Rev.Pre  | Preliminary Version  |
| 2020/04/08 | Rev.A.0  | Initial Released   |
| 2021/07/05 | Rev.A.1  | 1. Added Tape and Reel Information<br>2. Added description of PG pin and PG function |
| 2022/10/10 | Rev.A.2  | Updated the format of Package Outline Dimensions                                     |

## Pin Configuration and Functions

TPL9053-S Series  
DFN2X2-8 Package  
Top View



**Table 1. Pin Functions: TPL9053-S**

| Pin No. | Pin Name | I/O | Description   |
|---------|----------|-----|---|
| 7       | BYP      | I   | Bypass input pin. Connect a 10-nF ceramic capacitor from BYP to OUT to reduce output noise.   |
| 3       | EN       | 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.   |
| 6       | FB       | I   | Output voltage feedback pin. Connect to a resistor divider to adjust the output voltage.  |
| 2       | GND      | –   | Ground reference pin. Connect GND pin to PCB ground plane directly.   |
| 4       | GS       | –   | Internal reference pin. MUST connect GS pin to PCB ground plane directly.   |
| 1       | IN       | I   | Input voltage pin. Bypass IN to GND with a 10 $\mu$ F or greater capacitor.   |
| 8       | OUT      | O   | Regulated output voltage pin. Bypass OUT to GND with a 4.7 $\mu$ F or greater capacitor.  |
| 5       | PG       | I   | 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 LOW after the output voltage ramps above $V_{PG,TH}$ , and PG keeps HIGH when the output voltage is below the threshold. |

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

## 500-mA High PSRR, Ultra-low Noise LDO Regulator

## Specifications

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

| Parameter            |                                     | 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, Electrostatic Discharge Protection

| Symbol | Parameter                | Condition                             | Minimum Level | Unit |
|--------|--------------------------|---------------------------------------|---------------|------|
| HBM    | Human Body Model ESD     | ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup> | ±6            | 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               |                            | 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 Type | θ <sub>JA</sub> | θ <sub>JC</sub> | Unit |
|--------------|-----------------|-----------------|------|
| DFN2X2-8     | 120             | 20.3            | °C/W |

**500-mA High PSRR, Ultra-low Noise LDO Regulator**
**Electrical Characteristics**

All test condition:  $V_{IN} = V_{OUT(NOM)} + 1\text{ V}$ ,  $C_{IN} = 10\text{ }\mu\text{F}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $-40^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ , 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      | $\mu\text{A}$       |
| $I_{SHDN}$                                  | Shutdown Current                      | $EN = GND$  |       | 0.05  | 2        | $\mu\text{A}$       |
| <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        | $\mu\text{A}$       |
| <b>Regulated Output Voltage and Current</b> |                                       |   |       |       |          |                     |
| $V_{OUT}$                                   | Output Voltage Accuracy               | $-40^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$                            | -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                       | $V_{IN} = V_{OUT(NOM)} + 1\text{ V}$ ,<br>$I_{OUT} = 1\text{ mA to } 500\text{ mA}$ |       | 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 $\leq 50\text{ mV}$ ,<br>$T_A = 25^{\circ}\text{C}$          |       | 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                  | $I_{OUT} = 150\text{ mA}$ , $BW = 100\text{ Hz to } 80\text{ kHz}$                  |       | 5.7   |          | $\mu\text{V}_{RMS}$ |
| $t_{STR}$                                   | Start-up Time                         | $V_{OUT}$ reaches 95% of nominal output voltage after $EN = \text{high}$            |       | 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       | $V_{IN} = 5.5\text{ V}$ , $V_{FB} = 0.75\text{ V}$ , $T_A = 25^{\circ}\text{C}$     |       | 0.001 | 0.1      | $\mu\text{A}$       |
| $I_{BYP}$                                   | BYP Pin Current during Startup        |   |       | 1     |          | mA                  |

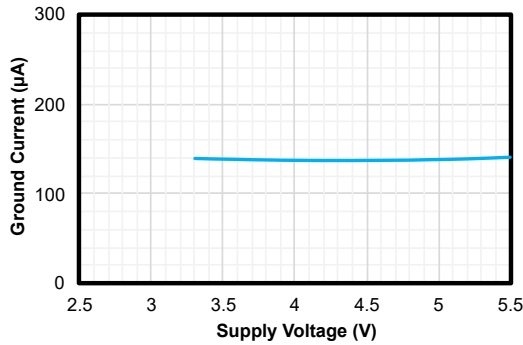
**500-mA High PSRR, Ultra-low Noise LDO Regulator**

| Parameter                        |  | Test Conditions   | Min | Typ  | Max | Unit        |
|----------------------------------|--|---|-----|------|-----|-------------|
| <b>Power Good</b>                |  |   |     |      |     |             |
| $V_{PG,TH}$                      | PG Threshold                             | OUT rising until PG is toggled  | 88% | 91%  | 94% | $V_{OUT}$   |
|                                  | PG Hysteresis                            |   |     | 2.5% |     | $V_{OUT}$   |
| $V_{PG,IL}$                      | PG Voltage Low                           | 1 mA to PG pin  |     | 10   | 100 | mV          |
| $I_{PG}$                         | PG Pin Leakage Current                   |   | -1  | 0.01 | 1   | $\mu A$     |
| <b>Transient Characteristics</b> |  |   |     |      |     |             |
| $\Delta V_{OUT}$                 | Line Transient                           | $V_{IN} = 3.8\text{ V to }4.8\text{ V}$ , rising and falling slew rate is $1\text{ V}/5\text{ }\mu s$ , $I_{OUT} = 500\text{ mA}$ |     | 3    |     | mVpp        |
|                                  | Load Transient                           | $I_{OUT} = 2\text{ mA to }100\text{ mA}$ in $1\text{ }\mu s$  |     | 10   |     | mVpp        |
|                                  |  | $I_{OUT} = 50\text{ mA to }500\text{ mA}$ in $1\text{ }\mu s$   |     | 20   |     | mVpp        |
| $V_{REV,TH}$                     | IN-OUT Reverse Voltage Turnoff Threshold | $V_{OUT} - V_{IN}$ when the input voltage falls   |     | 19   |     | mV          |
| <b>Temperature Range</b>         |  |   |     |      |     |             |
| $T_{SD}$                         | Thermal Shutdown Temperature             |   |     | 165  |     | $^{\circ}C$ |
|                                  | Thermal Shutdown Hysteresis              |   |     | 15   |     | $^{\circ}C$ |

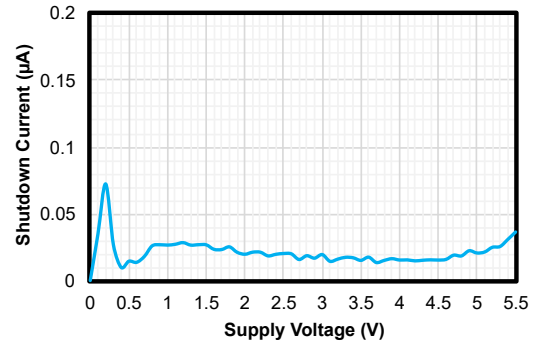
(1) The dropout voltage is defined as  $V_{DO} = V_{IN} - V_{OUT}$ . For  $V_{IN} \geq 3.6\text{ V}$  condition, the dropout voltage is measured when the FB pin voltage is forced at  $0.58\text{ V}$ . For  $V_{IN} = 1.7\text{ V}$  condition, the dropout voltage is guaranteed by design.

## Typical Performance Characteristics

All test condition:  $V_{IN} = 5\text{ V}$ ,  $V_A = +25^\circ\text{C}$ , unless otherwise noted.

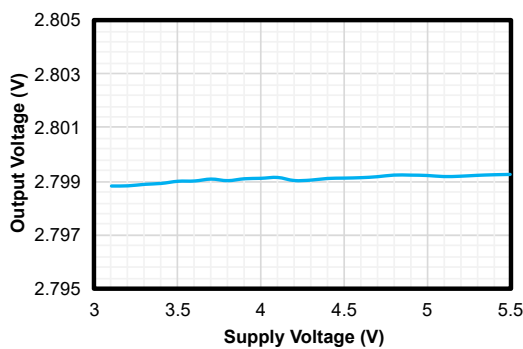


**Figure 1. Quiescent Current vs Input Voltage**



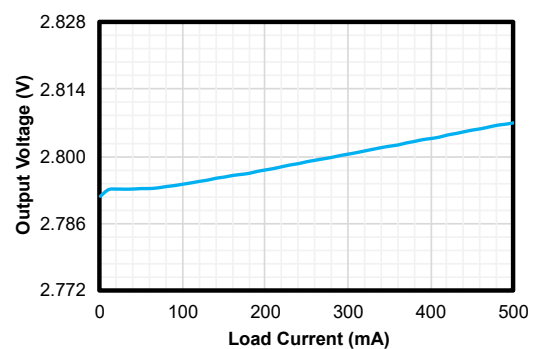
EN = GND

**Figure 2. Quiescent Current vs Input Voltage**

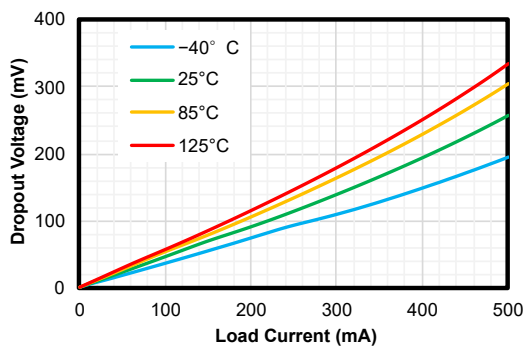


$I_{OUT} = 1\text{ mA}$

**Figure 3. Line Regulation**

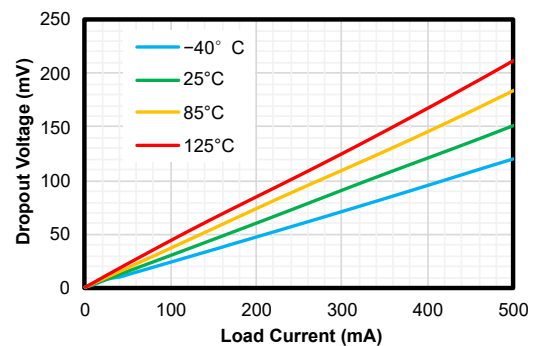


**Figure 4. Load Regulation**



$V_{OUT} = 1.8\text{ V}$

**Figure 5. Dropout Voltage vs Output Current**



$V_{OUT} = 2.8\text{ V}$

**Figure 6. Dropout Voltage vs Output Current**



# 500-mA High PSRR, Ultra-low Noise LDO Regulator

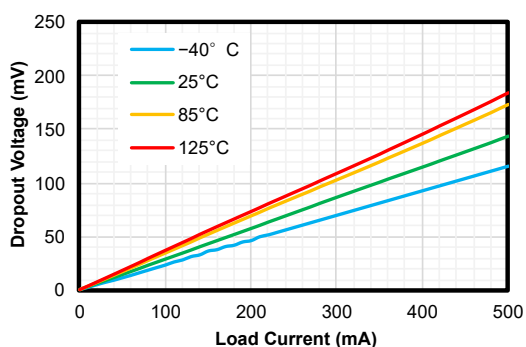

 $V_{OUT} = 3.3\text{ V}$ 

Figure 7. Dropout Voltage vs Output Current

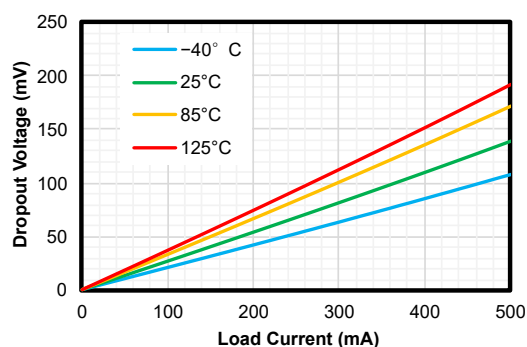

 $V_{OUT} = 5.0\text{ V}$ 

Figure 8. Dropout Voltage vs Output Current

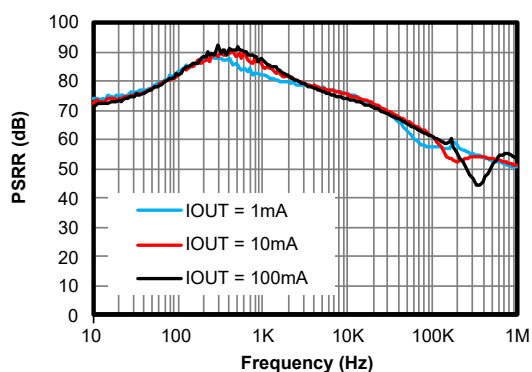

 $C_{BYP} = 10\text{ nF}$ 

Figure 9. PSRR

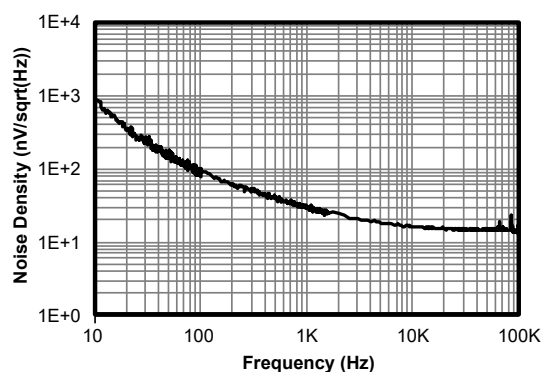

 $I_{OUT} = 280\text{ mA}$ 

Figure 10. Output Noise

## Detailed Description

### Overview

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

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

### Functional Block Diagram

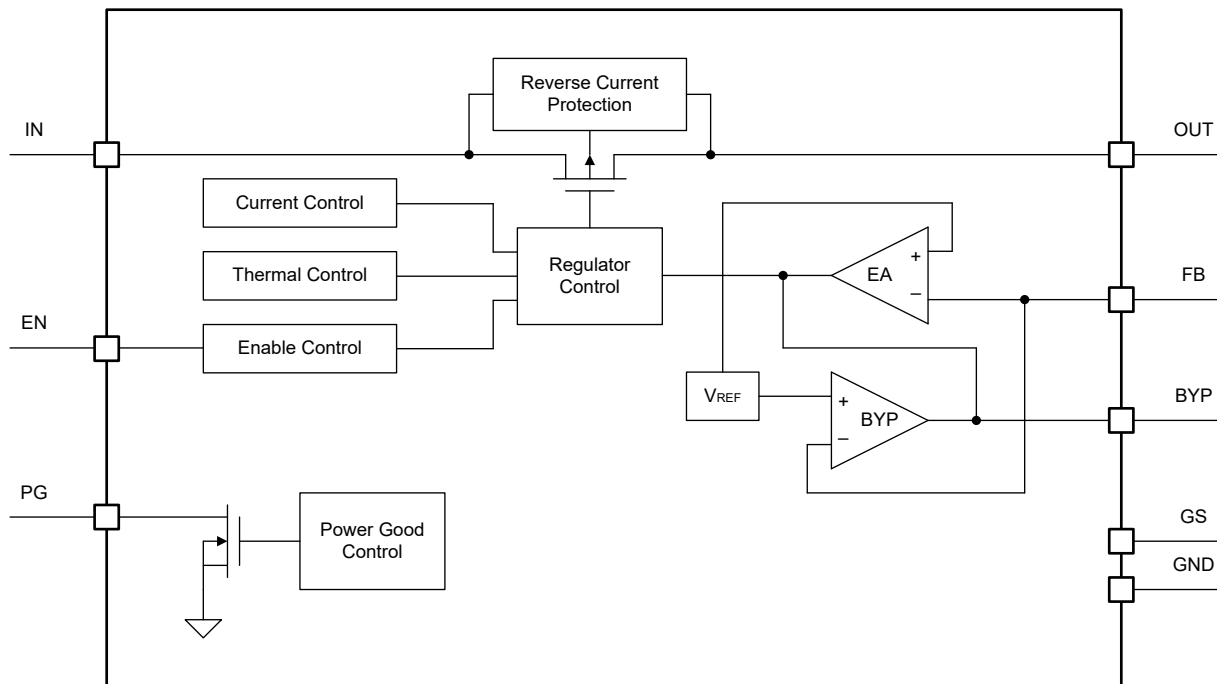


Figure 11. Functional Block Diagram

## 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 the TPL9053-S 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 k $\Omega$  and 120 k $\Omega$  to minimize FB input bias current error.

## 500-mA High PSRR, Ultra-low Noise LDO Regulator

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

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-S series integrates 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-S ramps up with a fixed slew rate. Under the room temperature condition, it takes 800  $\mu$ s from the rising edge of enable signal to the  $V_{OUT}$  reaching 95% of nominal output voltage. This start-up time is independent of the output capacitor and BYP capacitor, and the maximum 3-ms start-up time occurs under the  $-40^{\circ}\text{C}$  ambient temperature condition.

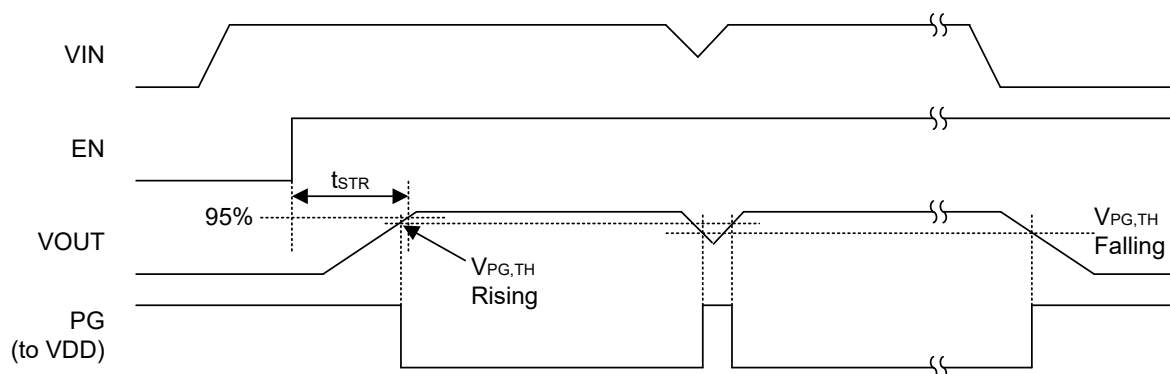
### Bypass (BYP)

The TPL9053-S series provides the BYP pin to reduce the regulator output noise and offers a feedback path to improve the transient response. Suggest connecting a capacitor from 1 nF to 100 nF from BYP to OUT.

### Power-Good Indicator (PG)

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

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



**Figure 12. Power Good Indication**

### Reverse-Current Protection

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

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

The TPL9053-S series integrates 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 limits 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).

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**500-mA High PSRR, Ultra-low Noise LDO Regulator**

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 use.

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

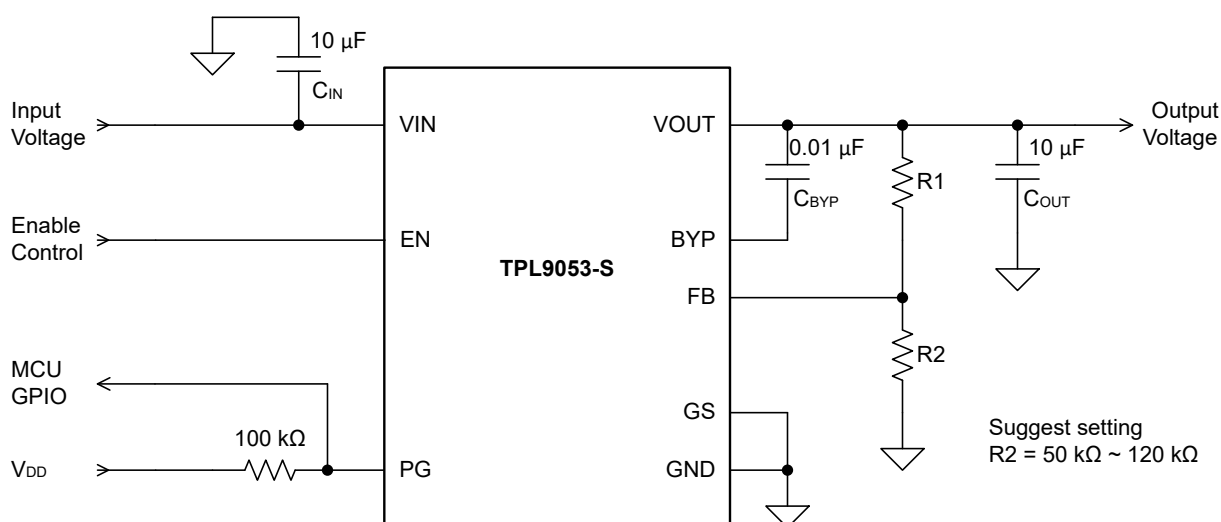
Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design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

## Application Information

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

## Typical Application

Figure 13 shows the typical application circuit of the TPL9053-S series.



**Figure 13. Typical Application Circuit**

### Input Capacitor and Output Capacitor

3PEAK recommends adding a 10-µF or greater capacitor with a 0.1-µF 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 TPL9053-S series requires an output capacitor of 4.7 µF or greater. 3PEAK recommends selecting an 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, the 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](#).

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**500-mA High PSRR, Ultra-low Noise LDO Regulator**

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

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

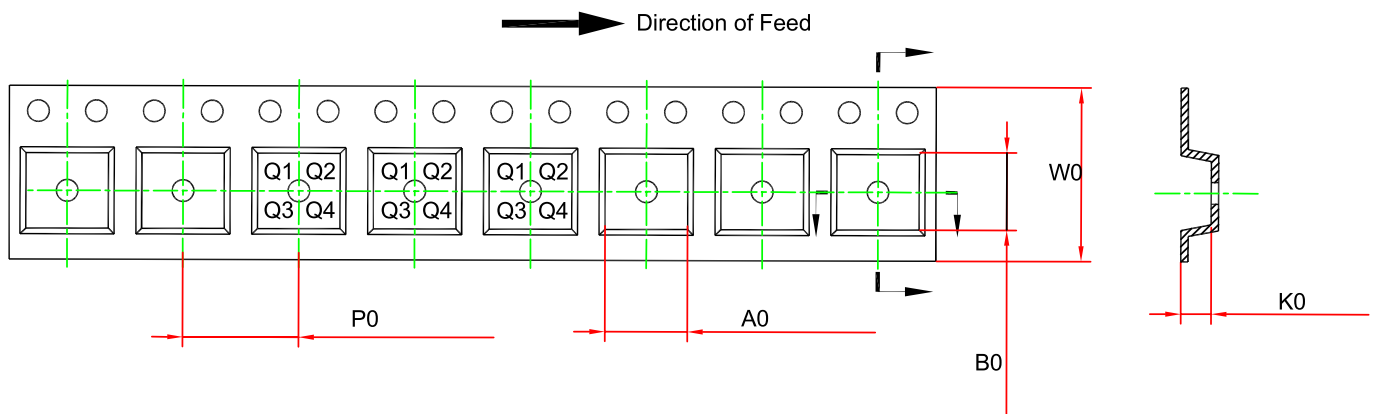
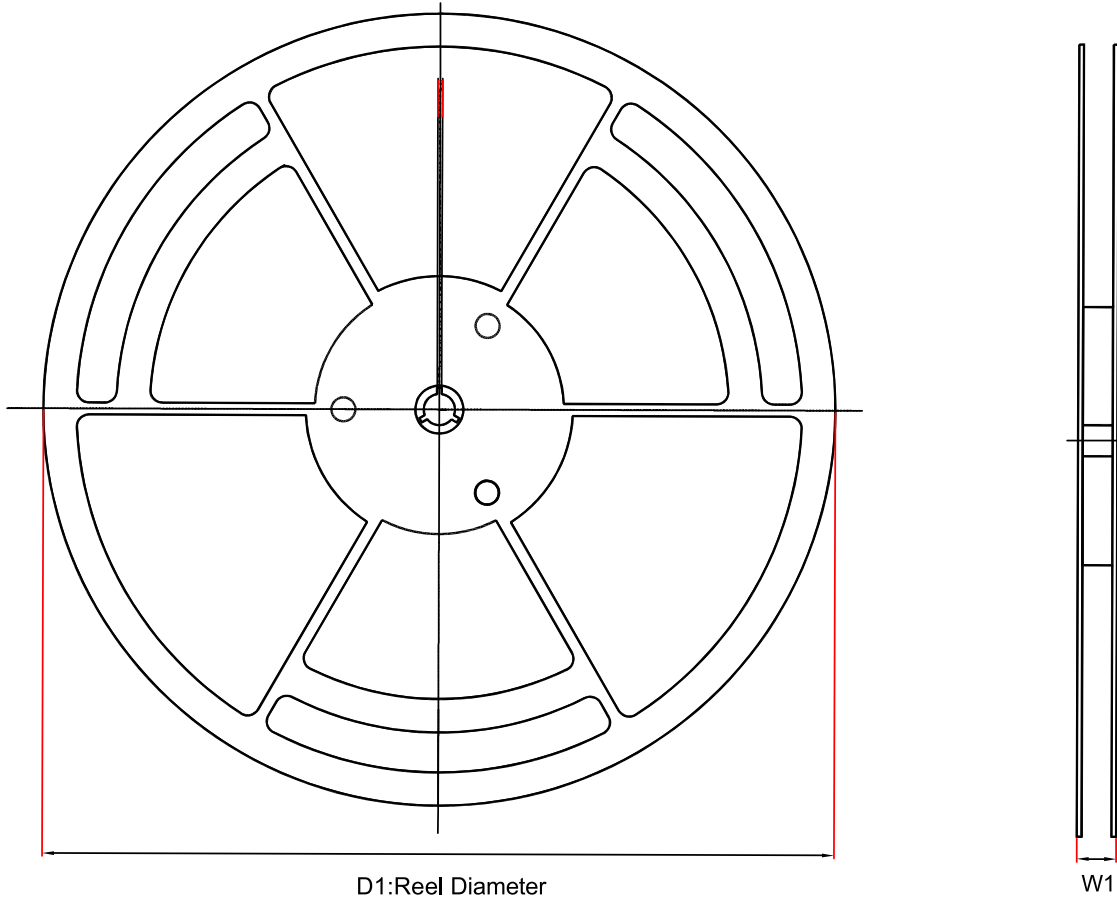
$$T_J = T_A + P_D \times \theta_{JA} \quad (3)$$

## Layout

### Layout Guideline

- Both input capacitors and output capacitors must be placed to the device pins as close as possible.
- 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 trace lengths or thick copper weight to minimize  $I \times R$  drop and heat dissipation.

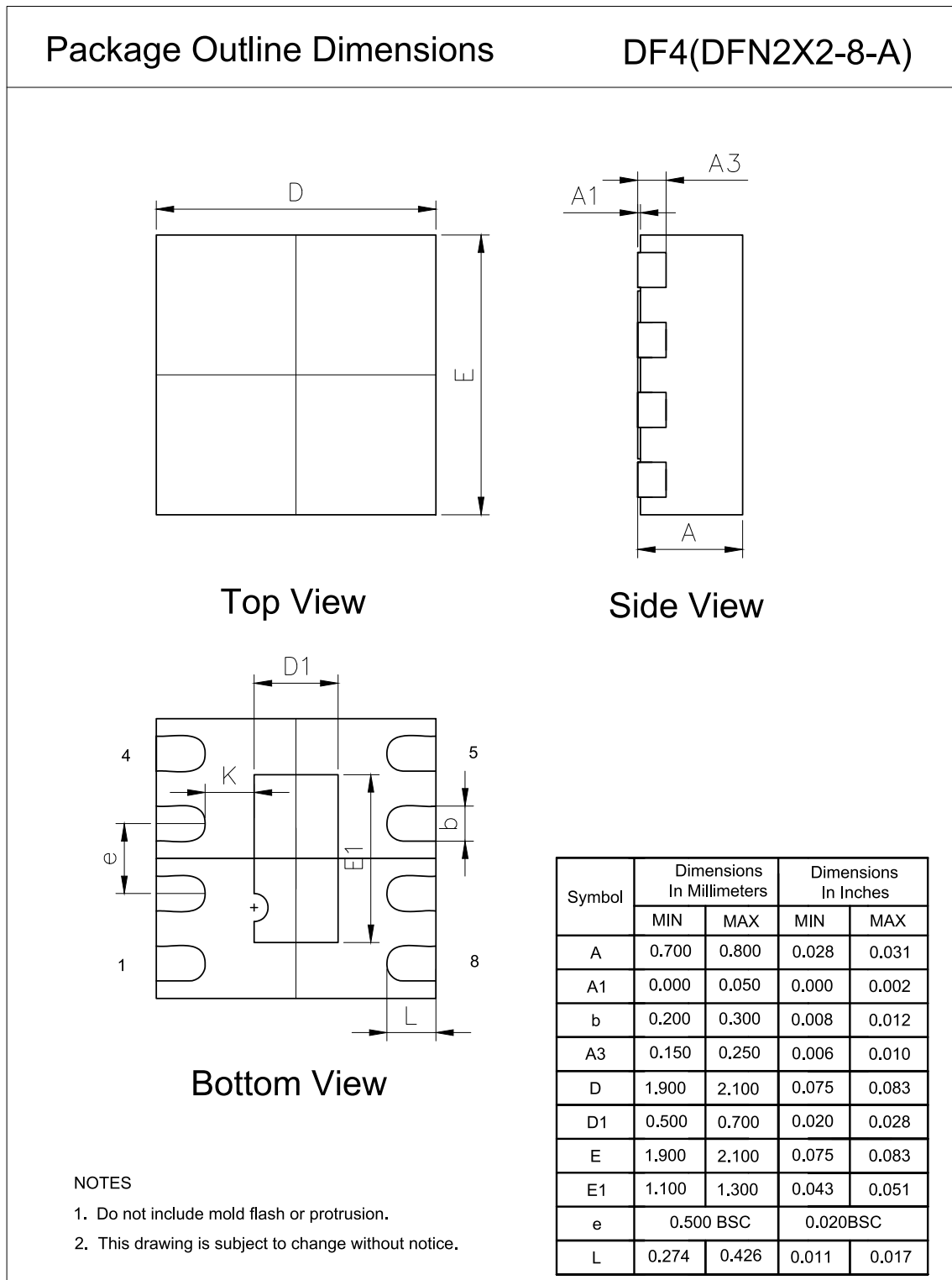
## Tape and Reel Information



| Order Number     | Package  | D1 (mm) | W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P0 (mm) | W0 (mm) | Pin1 Quadrant |
|------------------|----------|---------|---------|---------|---------|---------|---------|---------|---------------|
| TPL9053AD-DF4R-S | DFN2X2-8 | 180.0   | 13.1    | 2.3     | 2.3     | 1.1     | 4.0     | 8.0     | Q1            |



## Package Outline Dimensions

**DFN2X2-8**


## Order Information

| Order Number     | Operating Temperature Range | Package  | Marking Information | MSL | Transport Media, Quantity | Eco Plan |
|------------------|-----------------------------|----------|---------------------|-----|---------------------------|----------|
| TPL9053AD-DF4R-S | -40 to 125°C                | DFN2X2-8 | L905                | 3   | Tape and Reel, 3000       | Green    |

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

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