

## 3-A Sink and Source DDR Termination Regulator

### Features

- $V_{IN}$  Voltage: Support 2.5-V, 3.3-V, and 5-V Power Rails
- $V_{LDOIN}$  Voltage Range: 1.1 V to 3.5 V
- Flexible Input Voltage Tracking Directly from  $REFIN$  or through External Resistor Divider
- 3-A Sink and Source Current Capability for DDR Termination
- Integrated Power MOSFETs
- Output Remote Sensing
- Fast Load-Transient Response
- Open-Drain Power Good to Monitor  $OUT$  Regulation
- Built-in Soft-Start and UVLO, Current Limit, and Thermal Shutdown Protection
- Support DDR, DDR2, DDR3, DDR3L, Low-Power DDR3 and DDR4 VTT Applications
- Operating Temperature Range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- Small Package DFN3×3-10
- Pb-Free and RoHS-Compliant

### Applications

- Memory VTT Regulator for DDR, DDR2, DDR3, DDR3L, Low-Power DDR3 and DDR4
- Notebooks, Desktops, and Workstations
- Servers, Networking Equipment, and Datacenters
- Telecom and Base Station

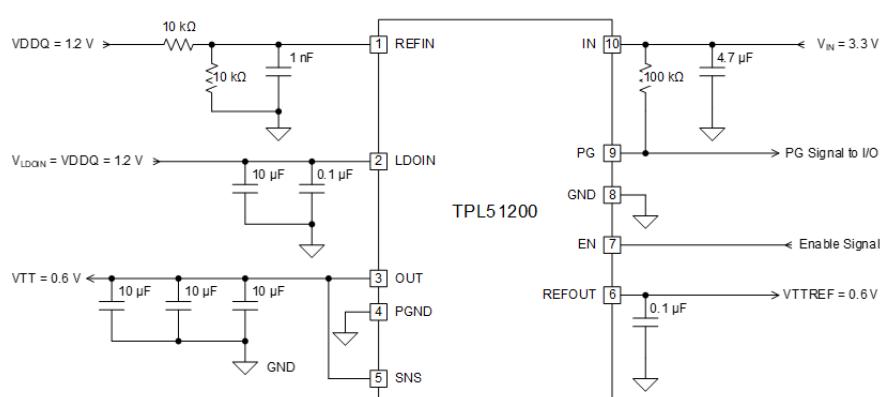
### Description

With the development of main processors in PCs and servers, more source double-data-rate (DDR) memories are required in the mainboard, where the input voltage becomes lower, and the space limitation becomes higher.

The TPL51200B is a series of the 3-A sink and source DDR termination regulators, specifically designed for DDR applications with heavy space limitations. The TPL51200B series implements a fast load-transient response and only requires a minimum output capacitance of 20  $\mu\text{F}$ .

The TPL51200B series supports a remote-sensing function and meets all power requirements for DDR VTT bus termination. In addition, the TPL51200B series provides an open-drain PG signal for VTT regulation indication, and an EN signal that can be used to discharge VTT for DDR applications.

The TPL51200B series is available in the thermally efficient DFN3×3-10 package with a thermal pad. The operating temperature range is from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .



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**3-A Sink and Source DDR Termination Regulator**

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**TPL51200B**

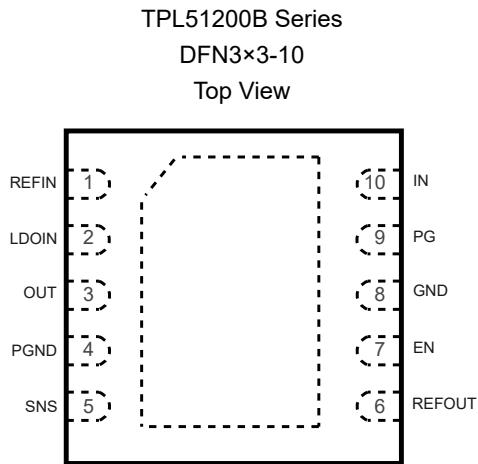
## **3-A Sink and Source DDR Termination Regulator**

### **Product Family Table**

Part Number	Output Current	Orderable Number	Package	Transport Media, Quantity	MSL	Marking information
TPL51200B	3 A	TPL51200B-DF8R	DFN3x3-10	4000	3	L200B

### **Revision History**

Date	Revision	Notes
2025-07-24	Rev.A.0	Released version.

**3-A Sink and Source DDR Termination Regulator**
**Pin Configuration and Functions**

**Table 1. Pin Functions**

Pin No.	Name	I/O	Description
1	REFIN	I	Reference input pin. For DDR applications, set to $V_{DDQ} / 2$ through a resistor divider.
2	LDOIN	I	LDO power supply input pin.
3	OUT	O	LDO output voltage pin. A total capacitance of 20- $\mu$ F or larger from OUT to GND (as close as possible to the OUT pin) is required to ensure regulator stability.
4	PGND	-	Power ground pin. Connect the PGND pin to the PCB ground plane directly.
5	SNS	I	LDO output voltage sense pin. Connect SNS to the remote DDR termination bypass capacitors to get accurate remote feedback sensing of OUT voltage.
6	REFOUT	O	Reference output pin. Connect to GND through a 0.1- $\mu$ F to 1- $\mu$ F ceramic capacitor.
7	EN	I	Regulators enable pin. Drive EN high to turn on the regulator. Drive EN low to turn off the regulator. For automatic startup, connect EN to $V_{IN}$ directly.
8	GND	-	Ground reference pin. Connect the GND pin to the PCB ground plane directly.
9	PG	O	Open-drain power-good output pin.
10	IN	I	Regulator power supply input pin. A 1- $\mu$ F or larger ceramic capacitor from IN to GND (as close as possible to the IN pin) is required to reduce the jitter from the previous-stage power supply.

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

**3-A Sink and Source DDR Termination Regulator**

## Specifications

### Absolute Maximum Ratings

Parameter		Min	Max	Unit
EN, IN, LDOIN, PG, REFIN, SNS		-0.3	6	V
PGND to GND		-0.3	0.3	V
OUT, REFOUT		-0.3	3.6	V
T <sub>J</sub>	Junction Temperature Range	-40	150	°C
T <sub>STG</sub>	Storage Temperature Range	-55	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.

(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	±2000	V
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002	±1500	V

### Recommended Operating Conditions

Parameter		Min	Max	Unit
IN	Regulator Input Voltage	2.375	5.5	V
LDOIN	LDO Input Voltage	-0.1	3.5	V
EN	Regulator Enable Voltage	-0.1	3.5	V
OUT	LDO Output Voltage	-0.1	3.5	V
SNS	LDO Output Sense Voltage	-0.1	3.5	V
REFIN	Reference Input Voltage	0.5	1.8	V
REFOUT	Reference Output Voltage	-0.1	1.8	V
PG	Power-Good Pull-Up Voltage	-0.1	3.5	V
PGND	Power Ground Voltage to GND	-0.1	0.1	V
T <sub>J</sub>	Junction Temperature Range	-40	125	°C

### Thermal Information

Package	θ <sub>JA</sub>	θ <sub>JB</sub>	θ <sub>JC, TOP</sub>	Unit
DFN3x3-10	42.07	10.08	75.14	°C/W

**3-A Sink and Source DDR Termination Regulator**
**Electrical Characteristics**

All test conditions:  $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  (typical value at  $T_J = +25^{\circ}\text{C}$ ),  $V_{IN} = V_{EN} = 3.3\text{ V}$ ,  $V_{LDOIN} = 1.8\text{ V}$ ,  $V_{REFIN} = 0.9\text{ V}$ ,  $V_{SNS} = 0.9\text{ V}$ ,  $C_{IN} = 10\text{ }\mu\text{F}$ , and  $C_{OUT} = 3 \times 10\text{ }\mu\text{F}$ , unless otherwise noted.

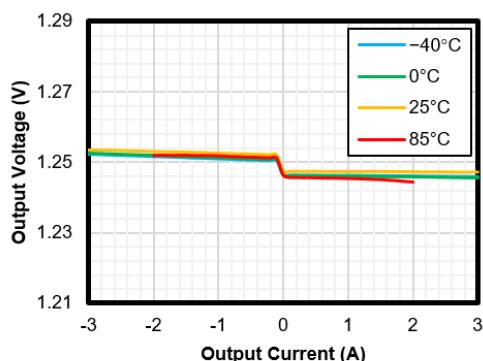
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Supply Input Voltage and Current</b>						
$V_{IN}$	Input Supply Voltage Range		2.375		5.5	V
$V_{LDOIN}$	LDO Input Voltage Range				3.5	V
UVLO <sub>IN</sub>	Input Supply UVLO	$T_A = 25^{\circ}\text{C}$ , $V_{IN}$ rising		2.3	2.375	V
	Hysteresis			50		mV
$I_{IN}$	Input Supply Current of IN	$T_A = 25^{\circ}\text{C}$ , $V_{EN} = 3.3\text{ V}$ , $I_{OUT} = 0\text{ mA}$		0.8	1	mA
$I_{IN\_SD}$	Shutdown Current of IN	$T_A = 25^{\circ}\text{C}$ , $V_{EN} = 0\text{ V}$ , $V_{REFIN} = 0\text{ V}$ , $I_{OUT} = 0\text{ mA}$		65	80	$\mu\text{A}$
		$T_A = 25^{\circ}\text{C}$ , $V_{EN} = 0\text{ V}$ , $V_{REFIN} > 0.4\text{ V}$ , $I_{OUT} = 0\text{ mA}$		200	400	$\mu\text{A}$
$I_{LDOIN}$	Input Current of LDOIN	$T_A = 25^{\circ}\text{C}$ , $V_{EN} = 3.3\text{ V}$ , $I_{OUT} = 0\text{ mA}$		1	50	$\mu\text{A}$
$I_{LDOIN\_SD}$	Shutdown Current of LDOIN	$T_A = 25^{\circ}\text{C}$ , $V_{EN} = 0\text{ V}$ , $I_{OUT} = 0\text{ mA}$		1	50	$\mu\text{A}$
<b>Reference Input and Output</b>						
$V_{REFIN}$	Reference Input Voltage		0.5		1.8	V
UVLO <sub>REFIN</sub>	Reference Input UVLO	$T_A = 25^{\circ}\text{C}$ , $V_{REFIN}$ rising	360	390	420	mV
	Hysteresis			20		mV
$I_{REFIN}$	Input Current of REFIN	$V_{EN} = 3.3\text{ V}$		1		$\mu\text{A}$
$V_{REFOUT}$	Reference Output Voltage			$V_{REFIN}$		V
$V_{REFOUT\_TOL}$	Tolerance of REfout to REFIN	$-1\text{ mA} \leq I_{REFOUT} \leq 1\text{ mA}$ $0.5\text{ V} \leq V_{REFIN} \leq 1.8\text{ V}$	-12		12	mV
		$-10\text{ mA} \leq I_{REFOUT} \leq 10\text{ mA}$ $0.5\text{ V} \leq V_{REFIN} \leq 1.8\text{ V}$	-15		15	mV
$I_{REFOUT\_SRCL}$	Source Current Limit of REfout	$V_{REFOUT} = 0.5\text{ V}$	30	60		mA
$I_{REFOUT\_SNKL}$	Sink Current Limit of REfout	$V_{REFOUT} = 1.5\text{ V}$	30	60		mA
<b>Regulated Output Voltage and Current</b>						
$V_{OUT}$	Output Voltage	$V_{REFOUT} = 1.25\text{ V (DDR1)}$ , $I_{OUT} = 0\text{ A}$		1.25		V
		Tolerance	-15		15	mV
		$V_{REFOUT} = 0.9\text{ V (DDR2)}$ ,		0.9		V

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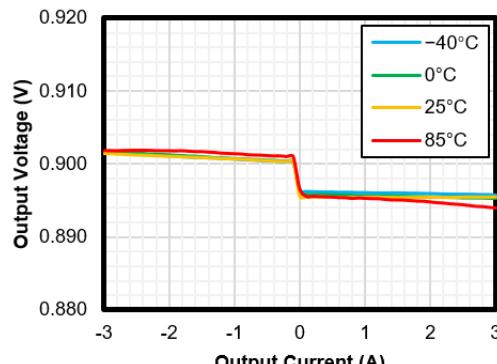
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		$I_{OUT} = 0 \text{ A}$				
		Tolerance	-15		15	mV
		$V_{REFOUT} = 0.75 \text{ V (DDR3)}, I_{OUT} = 0 \text{ A}$		0.75		V
		Tolerance	-15		15	mV
		$V_{REFOUT} = 0.675 \text{ V (DDR3L)}, I_{OUT} = 0 \text{ A}$		0.675		V
		Tolerance	-15		15	mV
		$V_{REFOUT} = 0.6 \text{ V (DDR4)}, I_{OUT} = 0 \text{ A}$		0.6		V
		Tolerance	-15		15	mV
$\Delta V_{OUT}$	Tolerance of OUT to REFOUT	$-2 \text{ A} < I_{OUT} < 2 \text{ A}$	-25		25	mV
$I_{OUT\_SRCL}$	Source Current Limit of OUT	$V_{SNS} = 90\% \times V_{REFOUT}$	3		4.5	A
$I_{OUT\_SNKL}$	Sink Current Limit of OUT	$V_{SNS} = 110\% \times V_{REFOUT}$	3.2		5.5	A
$R_{DIS}$	Discharge Resistance	$T_A = +25^\circ\text{C}, V_{REFIN} = 0 \text{ V}$ $V_{OUT} = 0.3 \text{ V}, V_{EN} = 0 \text{ V}$		12		$\Omega$
<b>Enable Control</b>						
$V_{EN}$	EN High-Level Input Voltage	Device enable	1.7			V
	EN Low-Level Input Voltage	Device disable			0.5	V
	Hysteresis			0.25		V
$I_{EN}$	Leakage Current of EN	$T_A = 25^\circ\text{C}$ $V_{EN} = 0 \text{ V to } 6.5 \text{ V}$	-1		1	$\mu\text{A}$
<b>Power Good</b>						
$V_{PG}$	PG Lower Threshold	With respect to REFOUT	-23.5	-20	-17.5	%
	PG Upper Threshold	With respect to REFOUT	17.5	20	23.5	%
	Hysteresis			5		%
$I_{PG}$	Current Leakage of PG				1	$\mu\text{A}$
$V_{OL(PG)}$	PG Low-Level Output Voltage	Source 4 mA to PG pin			0.4	V
$t_{DLY(PG)}$	PG Start-up Delay	Start-up rising edge, $V_{SNS}$ within 15% of $V_{REFOUT}$		2		ms
$t_{DLY(PG\_B)}$	PG Start-up Bad Delay	$V_{SNS}$ is beyond the $\pm 20\%$ PG trip threshold		10		$\mu\text{s}$
<b>Temperature Range</b>						
$T_{SD}$	Thermal Shutdown Threshold	Temperature increasing		155		$^\circ\text{C}$
	Hysteresis			25		$^\circ\text{C}$
$T_J$	Operating Junction Temperature		-40		125	$^\circ\text{C}$

**3-A Sink and Source DDR Termination Regulator**
**Typical Performance Characteristics**

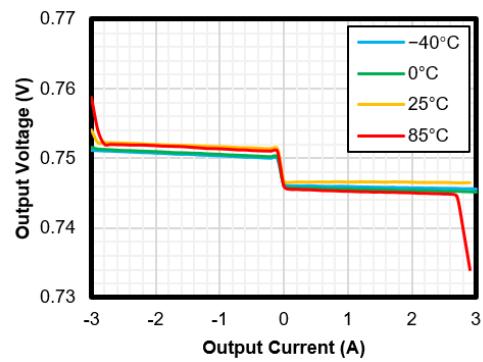
All test conditions:  $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  (typical value at  $T_J = +25^{\circ}\text{C}$ ),  $V_{IN} = V_{EN} = 3.3\text{ V}$ ,  $V_{LDOIN} = 1.8\text{ V}$ ,  $V_{REFIN} = 0.9\text{ V}$ ,  $V_{SNS} = 0.9\text{ V}$ ,  $C_{IN} = 10\text{ }\mu\text{F}$ , and  $C_{OUT} = 3 \times 10\text{ }\mu\text{F}$ , unless otherwise noted.


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

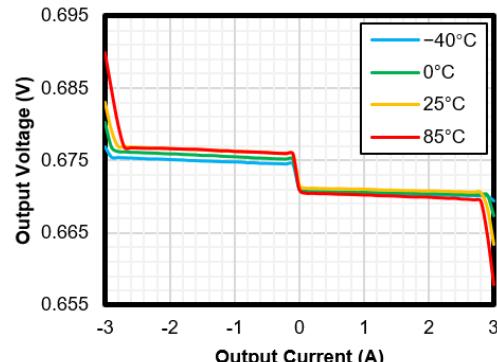
DDR

**Figure 1. OUT Load Regulation**

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

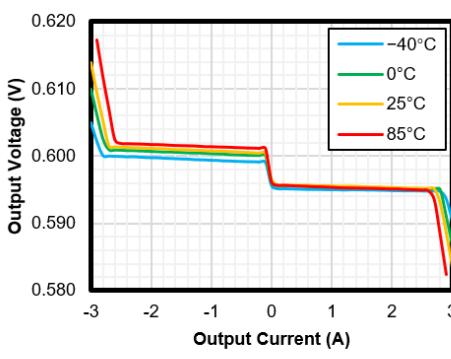
DDR2

**Figure 2. OUT Load Regulation**

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

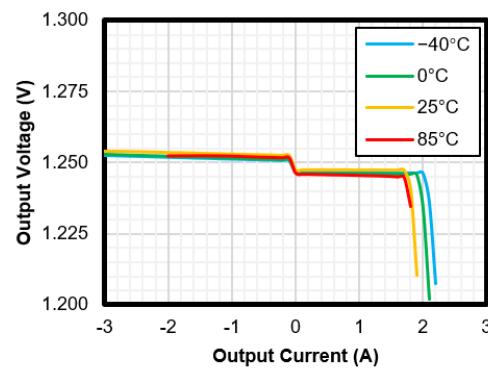
DDR3

**Figure 3. OUT Load Regulation**

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

DDR3L

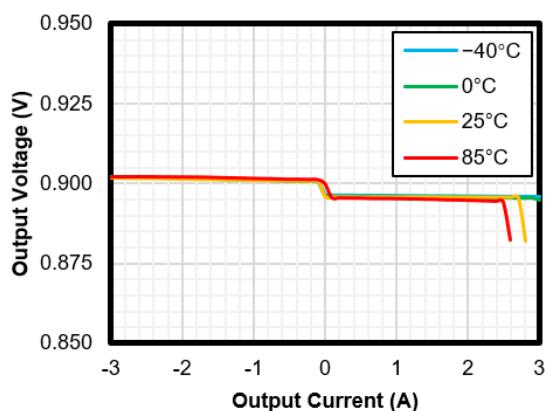
**Figure 4. OUT Load Regulation**

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

LP DDR3 or DDR4

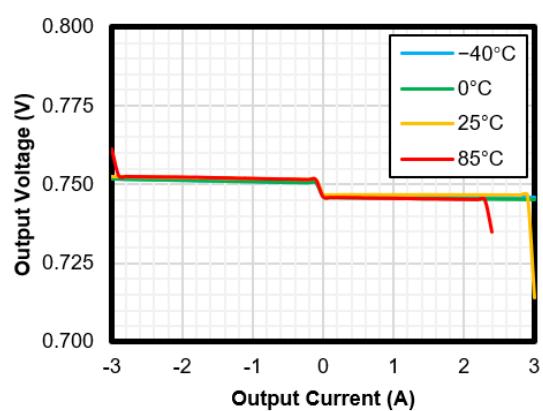
**Figure 5. OUT Load Regulation**

 $V_{IN} = 2.5\text{ V}$ 

DDR

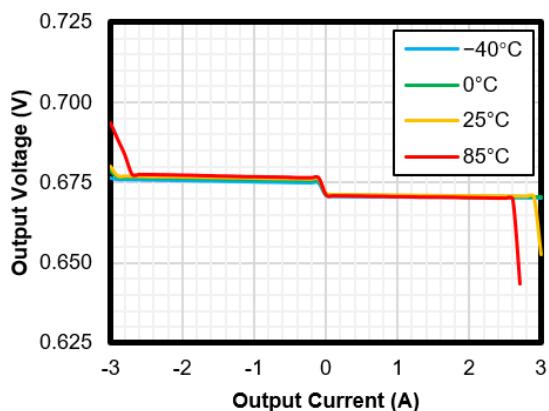
**Figure 6. OUT Load Regulation**

**3-A Sink and Source DDR Termination Regulator**

 $V_{IN} = 2.5 \text{ V}$ 

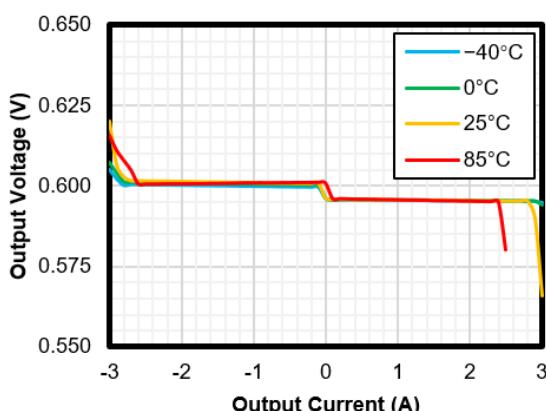
DDR2

**Figure 7. OUT Load Regulation**

 $V_{IN} = 2.5 \text{ V}$ 

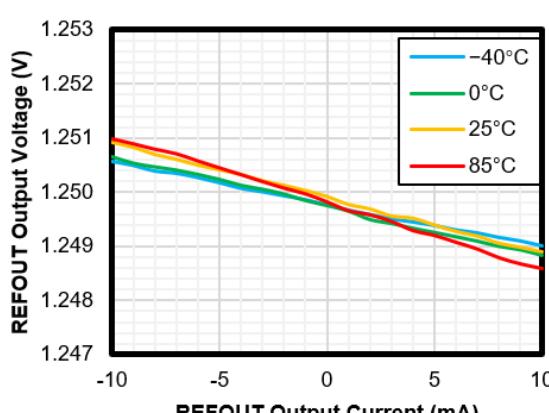
DDR3

**Figure 8. OUT Load Regulation**

 $V_{IN} = 2.5 \text{ V}$ 

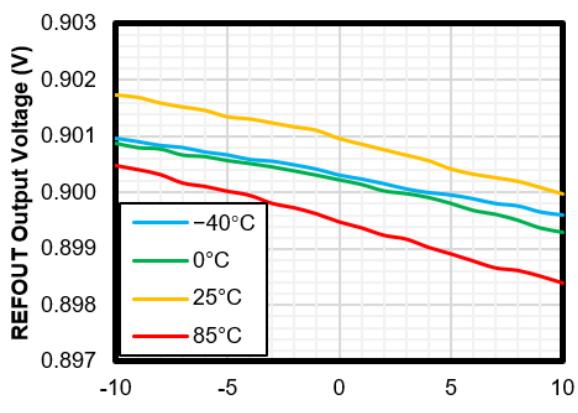
DDR3L

**Figure 9. OUT Load Regulation**

 $V_{IN} = 2.5 \text{ V}$ 

LP DDR3 or DDR4

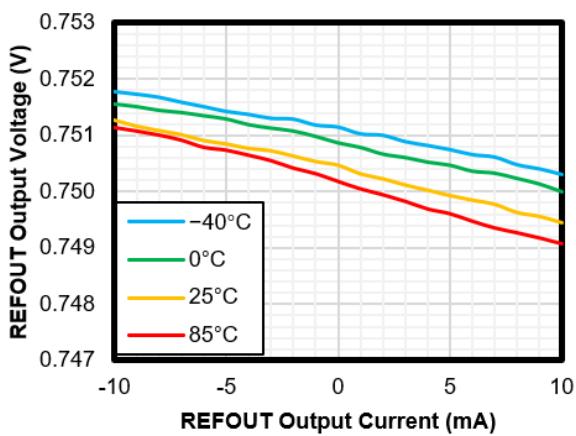
**Figure 10. OUT Load Regulation**


DDR

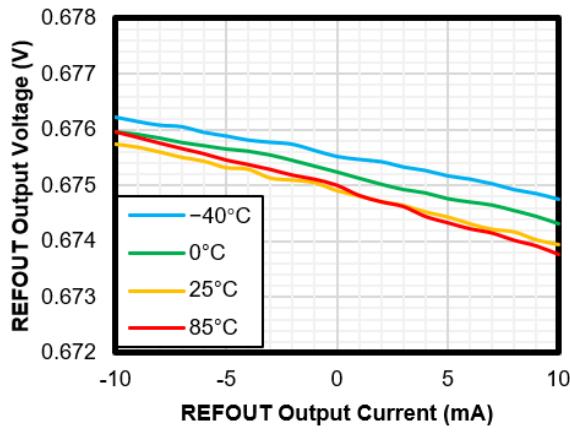
**Figure 11. REFOUT Load Regulation**


DDR2

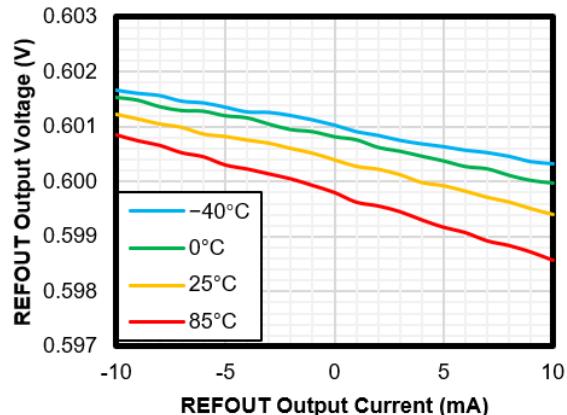
**Figure 12. REFOUT Load Regulation**

**3-A Sink and Source DDR Termination Regulator**


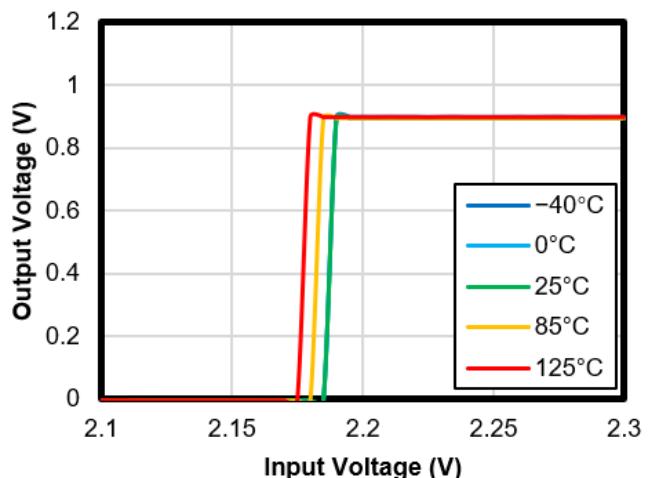
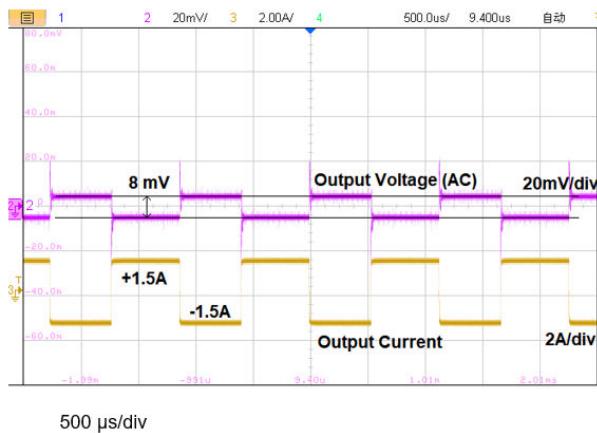
DDR3

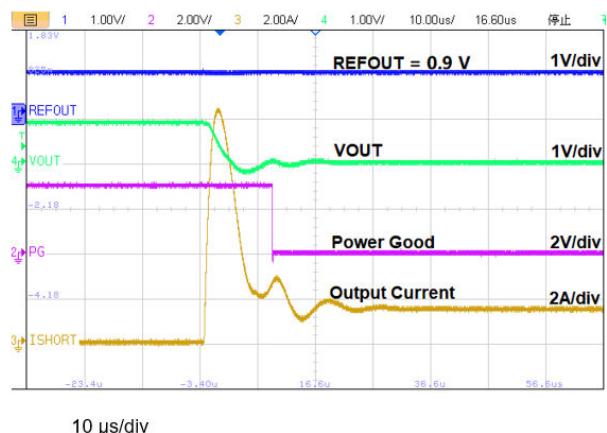
**Figure 13. REFOUT Load Regulation**


DDR3L

**Figure 14. REFOUT Load Regulation**


DDR4

**Figure 15. REFOUT Load Regulation**

**Figure 16. UVLO Rising**

 500  $\mu$ s/div

**Figure 17. Load Transient**

 10  $\mu$ s/div

**Figure 18. Output Short-to-GND Protection**

## Detailed Description

### Overview

The TPL51200B is a series of 3-A sink and source DDR termination regulators specifically designed for DDR applications with heavy space limitations. The TPL51200B series implements a fast load-transient response and only requires a minimum output capacitance of 20  $\mu$ F.

The TPL51200B series supports a remote-sensing function and meets all power requirements for DDR VTT bus termination. In addition, the TPL51200B series provides an open-drain PG signal for VTT regulation indication, and an EN signal that can be used to discharge VTT for DDR1 to DDR4 applications.

### Functional Block Diagram

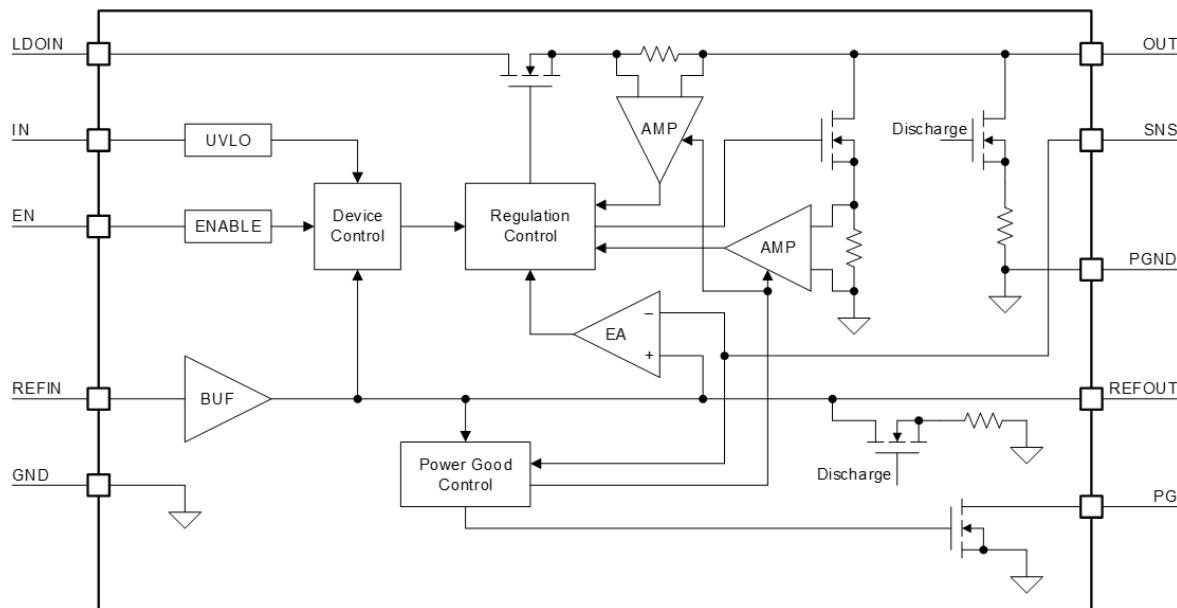


Figure 19. Functional Block Diagram

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## 3-A Sink and Source DDR Termination Regulator

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### Feature Description

#### **Sink and Source Regulator (OUT and SNS)**

The TPL51200B is a series of 3-A sink and source DDR termination regulators specifically designed for DDR applications with heavy space limitations. The TPL51200B series integrates a high-performance and low-dropout linear regulator with a fast-feedback loop that supports fast load transient response with small ceramic capacitors. To get tight regulation tolerance, the remote sensing pin, the SNS pin, must be connected to the OUT pin through a separate trace from the high current path.

#### **Voltage Reference (REFIN and REfout)**

The TPL51200B series uses the voltage at the REFIN pin as the reference voltage, and the output voltage at the REfout pin exactly follows the REFIN voltage within the tolerance of  $V_{REFOUT\_TOL}$ . When the TPL51200B series is configured for standard DDR applications, the voltage at the REFIN pin is divided through an external voltage divider from the DDR supply bus,  $V_{DDQ}$ .

The TPL51200B series supports the REFIN input voltage range from 0.5 V to 1.8 V. When the REFIN voltage is higher than the rising UVLO threshold of REFIN and the IN voltage is ready, there is a voltage regulated at the REfout pin, which the REfout pin is independent of the EN status.

#### **Enable Control (EN)**

The TPL51200B series integrates a high-active device enable control feature. Connect this pin to the GPIO of an external processor or digital logic control circuit to enable and disable the device.

#### **Under-Voltage Lockout (IN UVLO)**

The TPL51200B series uses an under-voltage lockout circuit to keep the regulator shut off until the IN voltage exceeds the rising UVLO threshold of IN.

#### **Power-Good Indicator (PG)**

The TPL51200B series integrates an open-drain output power good indicator. After regulator startup, the PG pin keeps low impedance until the output voltage enters the power-good window,  $\pm 20\%$  of REfout voltage. When output voltage enters the power-good window, the PG pin turns to high output impedance, and PG is pulled up to a high-voltage level after a 2-ms delay indicating the output voltage is ready. It is recommended to connect a 100-k $\Omega$  pull-up resistor between the PG pin and the pull-up voltage supply.

#### **Over-Current Protection**

The TPL51200B series integrates constant over-current protection. When the output voltage exits the power-good window,  $\pm 20\%$  of the REfout voltage, the current-limit level reduces 50% of the full level. After the output voltage enters the power-good window, the current-limit level is released to the full level.

#### **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 the device lifetime for long-term use is reduced.

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 thermal shutdown threshold minus thermal shutdown hysteresis, the regulator turns on again.

## 3-A Sink and Source DDR Termination Regulator

## 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 TPL51200B is a series of 3-A sink and source DDR termination regulators specifically designed for DDR applications. [Figure 20](#) shows a typical usage of the TPL51200B series.

## Typical Application

## Adjustable Output Operation

[Figure 20](#) shows the typical application schematic of the TPL51200B series in DDR4 applications.

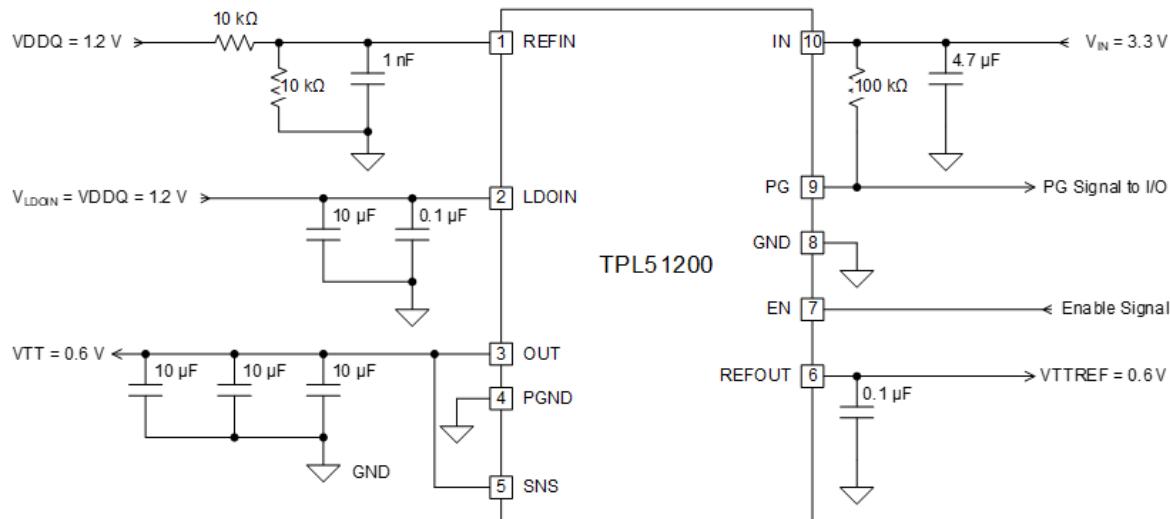


Figure 20. Typical Application Schematic

## IN Input Capacitor

3PEAK recommends placing a  $1\text{-}\mu\text{F}$  or greater capacitor with a  $0.1\text{-}\mu\text{F}$  bypass capacitor in parallel close to the IN pin to keep the input voltage stable. The voltage rating of the capacitors must be greater than the maximum input voltage.

## LDOIN Input Capacitor

3PEAK recommends placing a  $10\text{-}\mu\text{F}$  or greater capacitor with a  $0.1\text{-}\mu\text{F}$  bypass capacitor in parallel close to the LDOIN pin to keep the voltage stable during transients. More input capacitors are required if large output capacitors are used at the OUT pin. It is suggested to place input capacitors with half of the output capacitance value at the LDOIN pin.

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**3-A Sink and Source DDR Termination Regulator**

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**Output Capacitor**

To ensure stable operation, the TPL51200B series requires output capacitors of 20  $\mu$ F or greater. 3PEAK recommends selecting three 10- $\mu$ F X5R-or X7R-type ceramic capacitors in parallel to minimize the equivalent series resistance (ESR) and equivalent series inductance (ESL). The output capacitors must be placed as close to the OUT pin as possible.

**Power Dissipation**

During normal operation, the LDO junction temperature should not exceed 125°C. Use the equations below to calculate the power dissipation and estimate the junction temperature.

The power dissipation can be calculated using [Equation 1](#).

$$P_D = (V_{LDOIN} - V_{OUT}) \times I_{OUT} + V_{LDOIN} \times I_{GND} \quad (1)$$

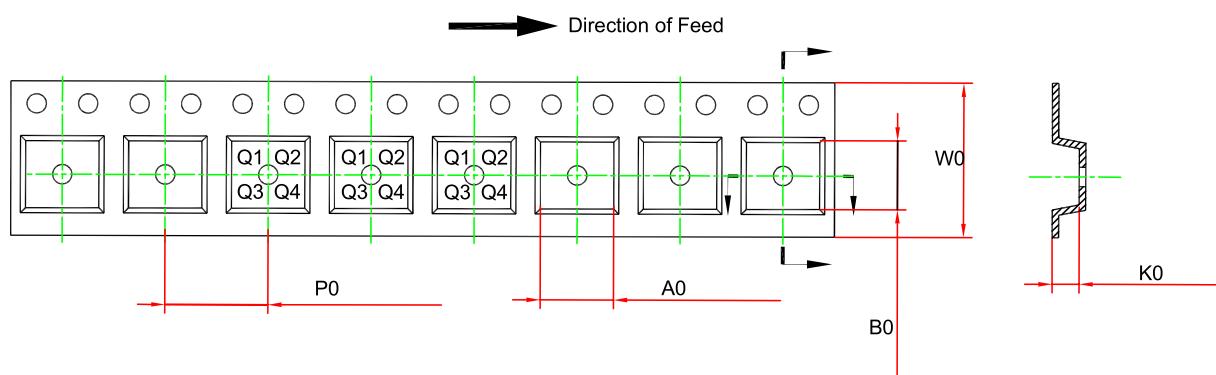
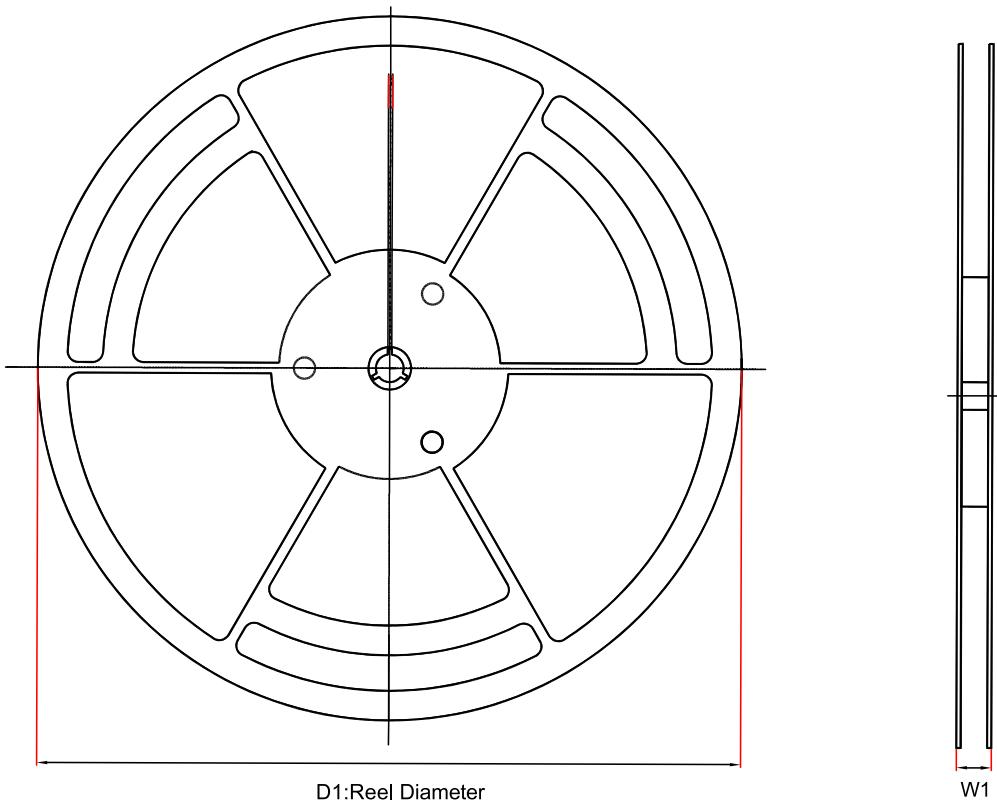
The junction temperature can be estimated using [Equation 2](#).  $\theta_{JA}$  is the junction-to-ambient thermal resistance.

$$T_J = T_A + P_D \times \theta_{JA} \quad (2)$$

## Layout

### Layout Guideline

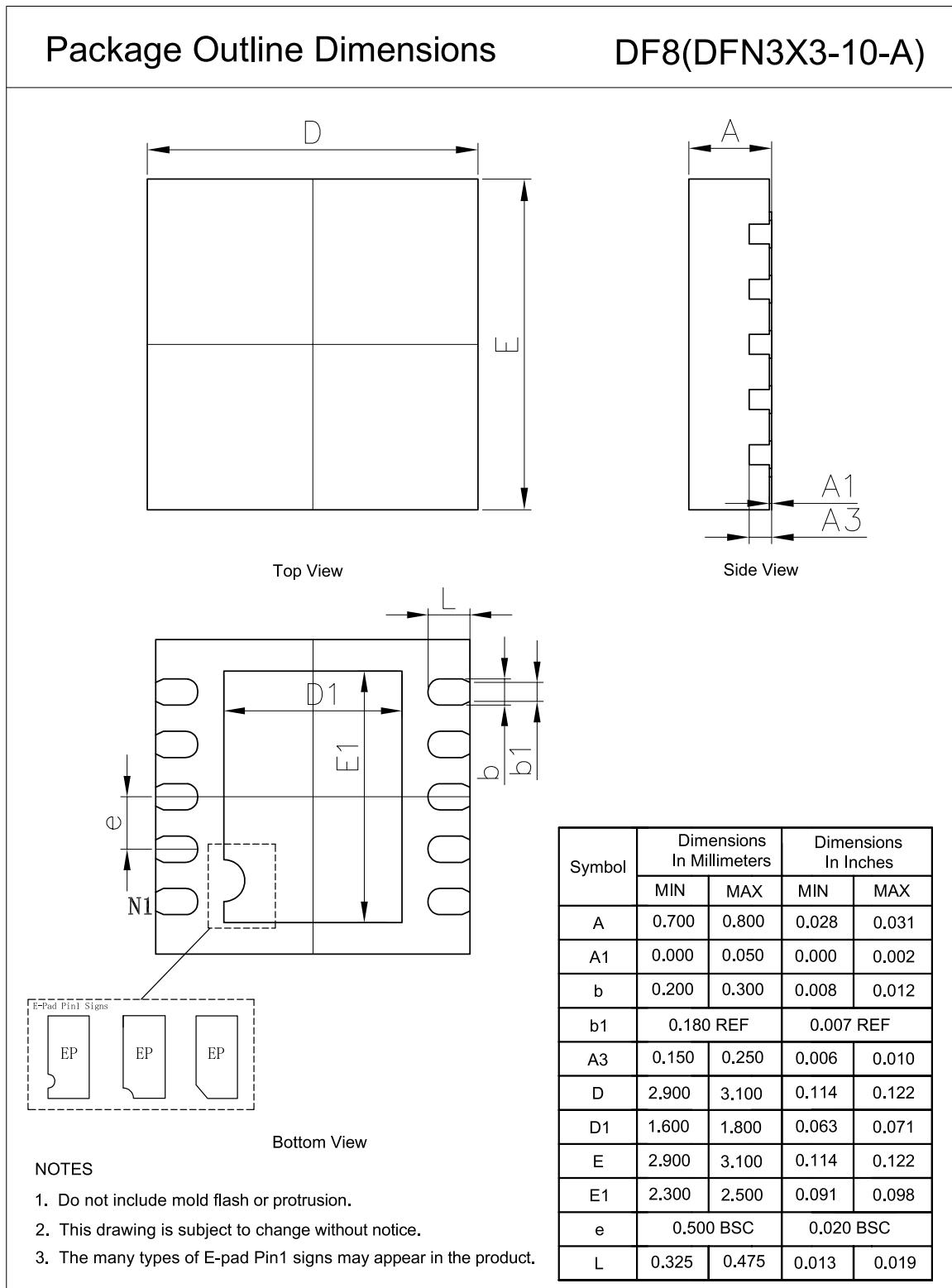
- Both input/output capacitors must be placed as close to the device pins as possible.
- Suggest bypassing the input pin to ground with a  $0.1 \mu\text{F}$  bypass capacitor. The loop area formed by the bypass capacitor connection, the voltage input pin, and the ground pin of the system must be as small as possible.
- Suggest using wide trace lengths or thick copper weight to minimize  $I \times R$  drop and heat dissipation.
- The GND pin and the PGND pin must be connected to the thermal pad with as many multiple thermal vias as possible connected to the internal ground planes.

**3-A Sink and Source DDR Termination Regulator**
**Tape and Reel Information**


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPL51200B-DF8R	DFN3×3-10	330	17.6	3.3	3.3	1.1	8	12	Q2

## Package Outline Dimensions

**DFN3X3-10**



## 3-A Sink and Source DDR Termination Regulator

## Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPL51200B-DF8R	-40 to 125°C	DFN3x3-10	L200B	3	4000	Green

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

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**TPL51200B**

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**3-A Sink and Source DDR Termination Regulator**

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