

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°C to $+125^{\circ}\text{C}$
- Small Package with DFN3x3-10
- 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 and more source double-data-rate (DDR) memories are required in the mainboard, where the input voltage becomes lower and lower, and space limitation becomes increasingly higher.

The TPL51200X is a series of 3-A sink and source DDR termination regulators specifically designed for DDR applications with heavy space limitations. The TPL51200X series implements a fast load-transient response and only requires a minimum output capacitance of 20 μF .

The TPL51200X series supports a remote-sensing function and all power requirements for DDR VTT bus termination. In addition, the TPL51200X 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 TPL51200X series is available in the thermally efficient DFN3x3-10 package with a thermal pad, and supports the operating temperature range from -40°C to $+125^{\circ}\text{C}$.

Typical Application Circuit

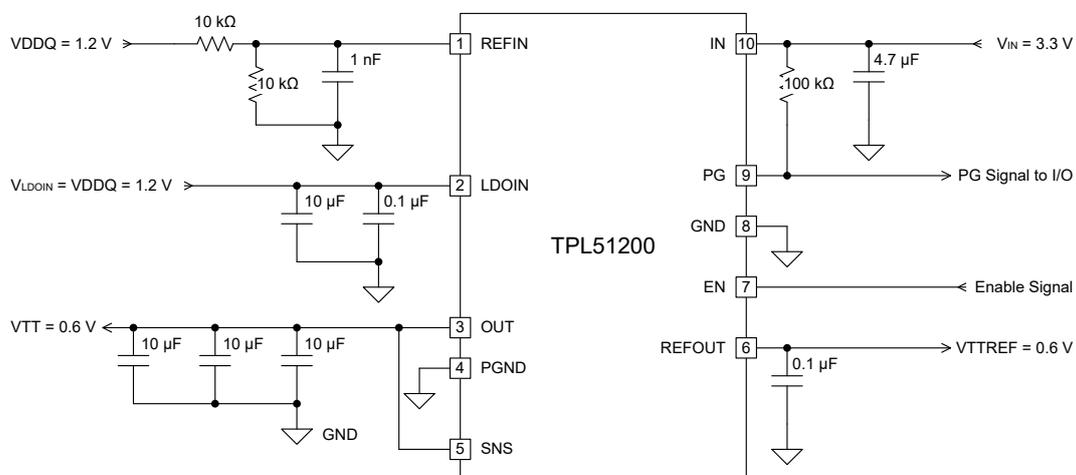


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Product Family Table

Part Number	Output Current	Orderable Number	Package	Transport Media, Quantity	MSL	Marking information
TPL51200X	3 A	TPL51200X-DF8R	DFN3x3-10	4,000	MSL3	L200X

Revision History

Date	Revision	Notes
2026-01-15	Rev.A.0	Released version

Pin Configuration and Functions

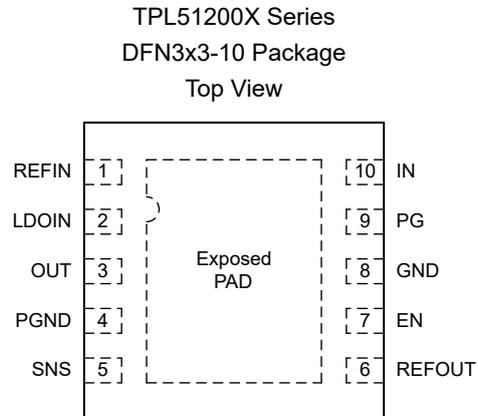


Table 1. Pin Functions: TPL51200X

Pin		I/O	Description
No.	Name		
7	EN	I	Regulator enable pin. Drive EN high to turn on the regulator; drive EN low to turn off the regulator. For automatic startup, connect EN to VDDQ directly.
8	GND	–	Ground reference pin. Connect the GND pin to the PCB ground plane directly.
10	IN	I	Regulator power supply input pin. A 1- μ F or larger ceramic capacitor from IN to ground (as close as possible to the IN pin) is required to reduce the jitter from the previous-stage power supply.
2	LDOIN	I	LDO power supply input pin.
3	OUT	O	LDO output voltage pin. Total capacitance of 20- μ F or larger from OUT to ground (as close as possible to the OUT pin) is required to ensure regulator stability.
9	PG	O	Open-drain power-good output pin.
4	PGND	–	Power ground pin. Connect the PGND pin to the PCB ground plane directly.
1	REFIN	I	Reference input pin. For the DDR application, set to VDDQ/2 through a resistor divider.
6	REFOUT	O	Reference output pin. Connect to ground through a 0.1- μ F to 1- μ F ceramic capacitor.
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.

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

3-A Sink and Source DDR Termination Regulator
Specifications
Absolute Maximum Ratings

Parameters		Min	Max	Unit
EN, IN, LDOIN, PG, REFIN, SNS		-0.3	6.5	V
PGND to GND		-0.3	0.3	V
OUT, REFOUT		-0.3	3.6	V
T _J	Junction Temperature Range	-40	150	°C
T _{STG}	Storage Temperature Range	-55	150	°C
T _L	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) This data was taken with the JEDEC low effective thermal conductivity test board.

ESD, Electrostatic Discharge Protection

Parameter		Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±2000	V
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 ⁽²⁾	±1500	V

(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	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 _J	Junction Temperature Range	-40	125	°C

Thermal Information

Package	θ_{JA}	θ_{JB}	$\theta_{JC, TOP}$	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.

Parameter		Conditions	Min	Typ	Max	Unit
Supply Voltage and Current						
V_{IN}	Input Supply Voltage Range		2.375		5.5	V
V_{LDOIN}	LDO Input Voltage Range				3.5	V
$UVLO_{IN}$	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	μA
		$T_A = +25^{\circ}\text{C}$, $V_{EN} = 0\text{ V}$, $V_{REFIN} > 0.4\text{ V}$, $I_{OUT} = 0\text{ mA}$		200	400	μA
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	μA
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	μA
Reference Input and Output						
V_{REFIN}	Reference Input Voltage		0.5		1.8	V
$UVLO_{REFIN}$	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		μA
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	$V_{REFOUT} = 0.5\text{ V}$	10	60		mA
I_{REFOUT_SNKL}	Sink Current Limit of REFOUT	$V_{REFOUT} = 1.5\text{ V}$	10	60		mA
Regulated Output Voltage and Current						
V_{OUT}	Output Voltage	$V_{REFOUT} = 1.25\text{ V (DDR1)}$, $I_{OUT} = 0\text{ A}$		1.25		V
		Tolerance	-15		15	mV
		$V_{REFOUT} = 0.9\text{ V (DDR2)}$, $I_{OUT} = 0\text{ A}$		0.9		V
		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

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Parameter		Conditions	Min	Typ	Max	Unit
		$V_{REFOUT} = 0.6\text{ V (DDR4)}, I_{OUT} = 0\text{ A}$		0.6		V
		Tolerance	-15		15	mV
ΔV_{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		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		Ω
Enable Control						
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	μA
Power Good						
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}	Leakage Current of PG				1	μA
$V_{OL(PG)}$	PG Low-level Output Voltage	Source 4 mA to PG pin			0.4	V
$t_{DLY(PG)}$	PG Start-up Delay	Startup 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		μs
Temperature Range						
T_{SD}	Thermal Shutdown Threshold	Temperature increasing		155		$^\circ\text{C}$
	Hysteresis			25		$^\circ\text{C}$
T_J	Operating Junction Temperature		-40		125	$^\circ\text{C}$

Detailed Description

Overview

The TPL51200X is a series of 3-A sink and source DDR termination regulators specifically designed for DDR applications with heavy space limitations. The TPL51200X series implements a fast load-transient response and only requires a minimum output capacitance of 20 μF .

The TPL51200X series supports a remote-sensing function and meets all power requirements for DDR VTT bus termination. In addition, the TPL51200X 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

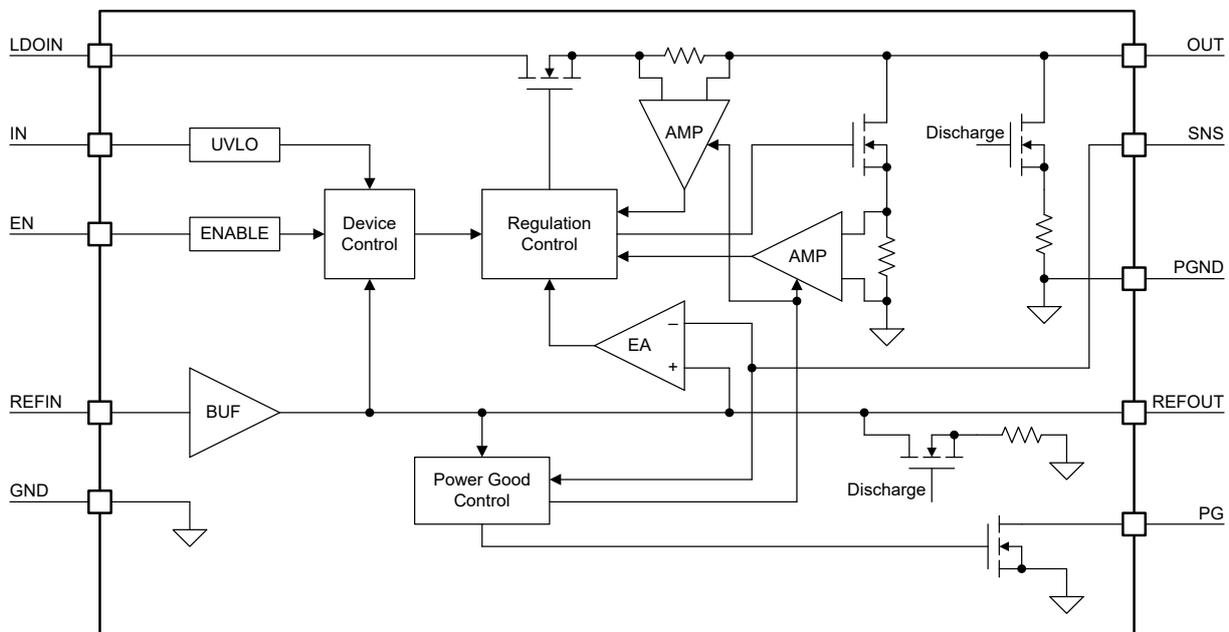


Figure 1. Functional Block Diagram

Feature Description

Sink and Source Regulator (OUT and SNS)

The TPL51200X is a series of 3-A sink and source DDR termination regulators specifically designed for DDR applications with heavy space limitations. The TPL51200X series integrates a high-performance, low-dropout linear regulator with a fast-feedback loop that can support fast load transient response with small ceramic capacitors. To get tight regulation tolerance, the remote sensing pin, and SNS pin, must be connected to the OUT pin through a separate trace from the high current path.

Voltage Reference (REFIN and REFOUT)

The TPL51200X series uses the voltage at the REFIN pin as the reference voltage. The output voltage at the REFOUT pin exactly follows the REFIN voltage within the tolerance of VREFOUT_TOL. When the TPL51200X 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, VDDQ.

The TPL51200X 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 voltage regulated at the REFOUT pin. The REFOUT pin is independent of the EN status.

Enable Control (EN)

The TPL51200X series integrates the 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 TPL51200X 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 TPL51200X 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 the 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 to indicate the output voltage is ready. It is recommended to connect a 100-k Ω pull-up resistor between the PG pin and the pull-up voltage supply.

Over-Current Protection

The TPL51200X series integrates constant over-current protection. When the output voltage exists in 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°C to 125°C . When the junction temperature is between 125°C and the thermal shutdown (TSD) threshold, the regulator can still work well, but the lifetime of the device 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.

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 TPL51200X is a series of 3-A sink and source DDR termination regulators specifically designed for DDR applications. The following application schematic shows a typical usage of the TPL51200X series.

Typical Application

Figure 2 shows the typical application schematic of the TPL51200X series in DDR4 applications.

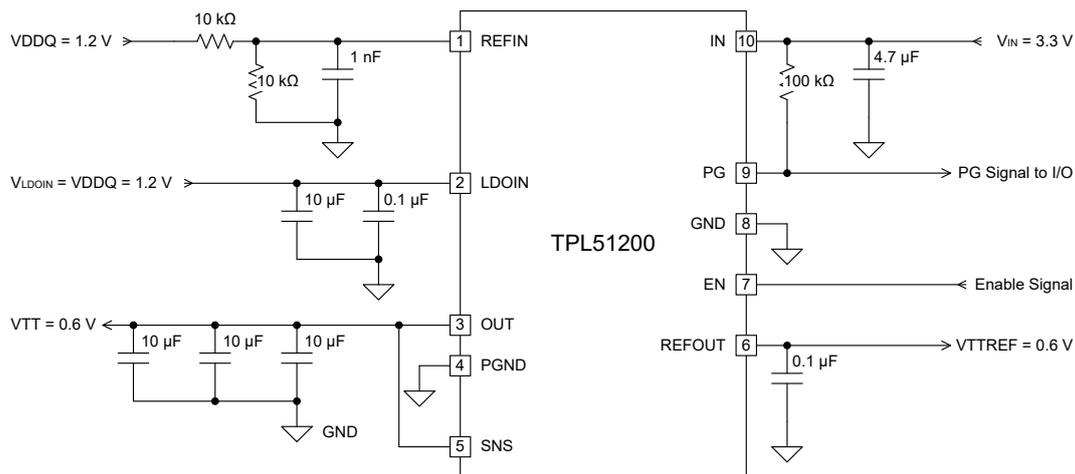


Figure 2. Typical Application Circuit

IN Input Capacitor

3PEAK recommends placing a 1- μ F or greater capacitor with a 0.1- μ 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- μ F or greater capacitor with a 0.1- μ F bypass capacitor in parallel close to the LDOIN pin to keep the voltage stable during transient. 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.

Output and SNS Output Capacitor

To ensure stable operation, the TPL51200X series requires output capacitors of 20 μ F or greater. 3PEAK recommends selecting three 10- μ 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. When using the remote sense function, to prevent the instability issue caused by parasitic parameters of the long output power trace, it is

3-A Sink and Source DDR Termination Regulator

recommended to keep the total capacitance of C_{OUT} between 10 μ F and 30 μ F, and the total capacitance of the remote DDR termination bypass capacitors should be greater than that of $3 \times C_{OUT}$.

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](#). θ_{JA} is the junction-to-ambient thermal resistance.

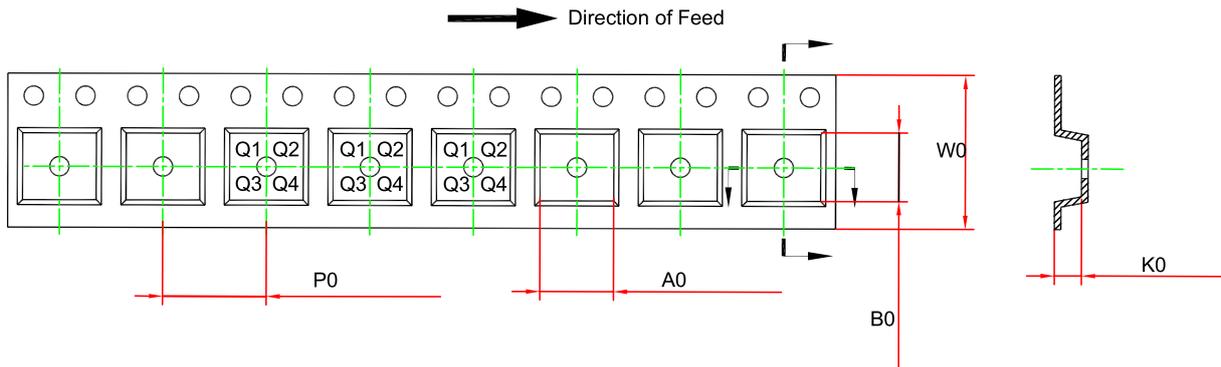
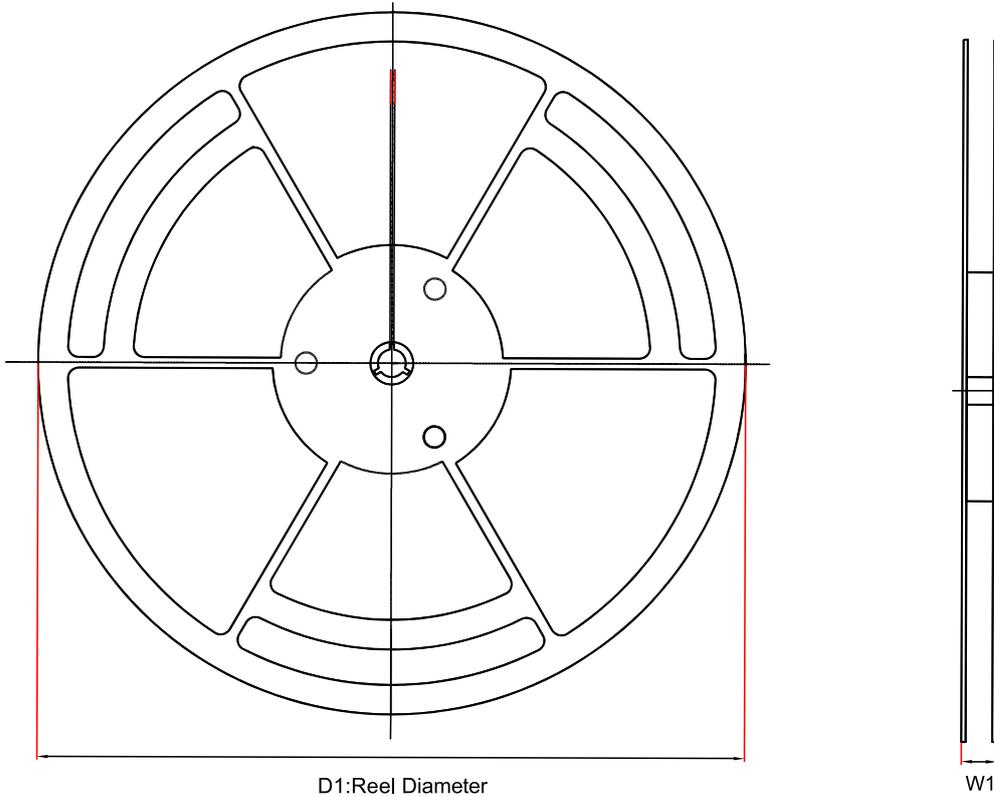
$$T_J = T_A + P_D \times \theta_{JA} \quad (2)$$

Layout

Layout Guidelines

- Both input capacitors and output capacitors must be placed as close to the device pins as possible.
- Suggest bypassing the input pin to ground with a 0.1- μ 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 and thick copper to minimize I \times R drop and heat dissipation.
- The GND pin and the PGND pin must be connected to the thermal pad with multiple thermal vias as many as possible connected to the internal ground planes.

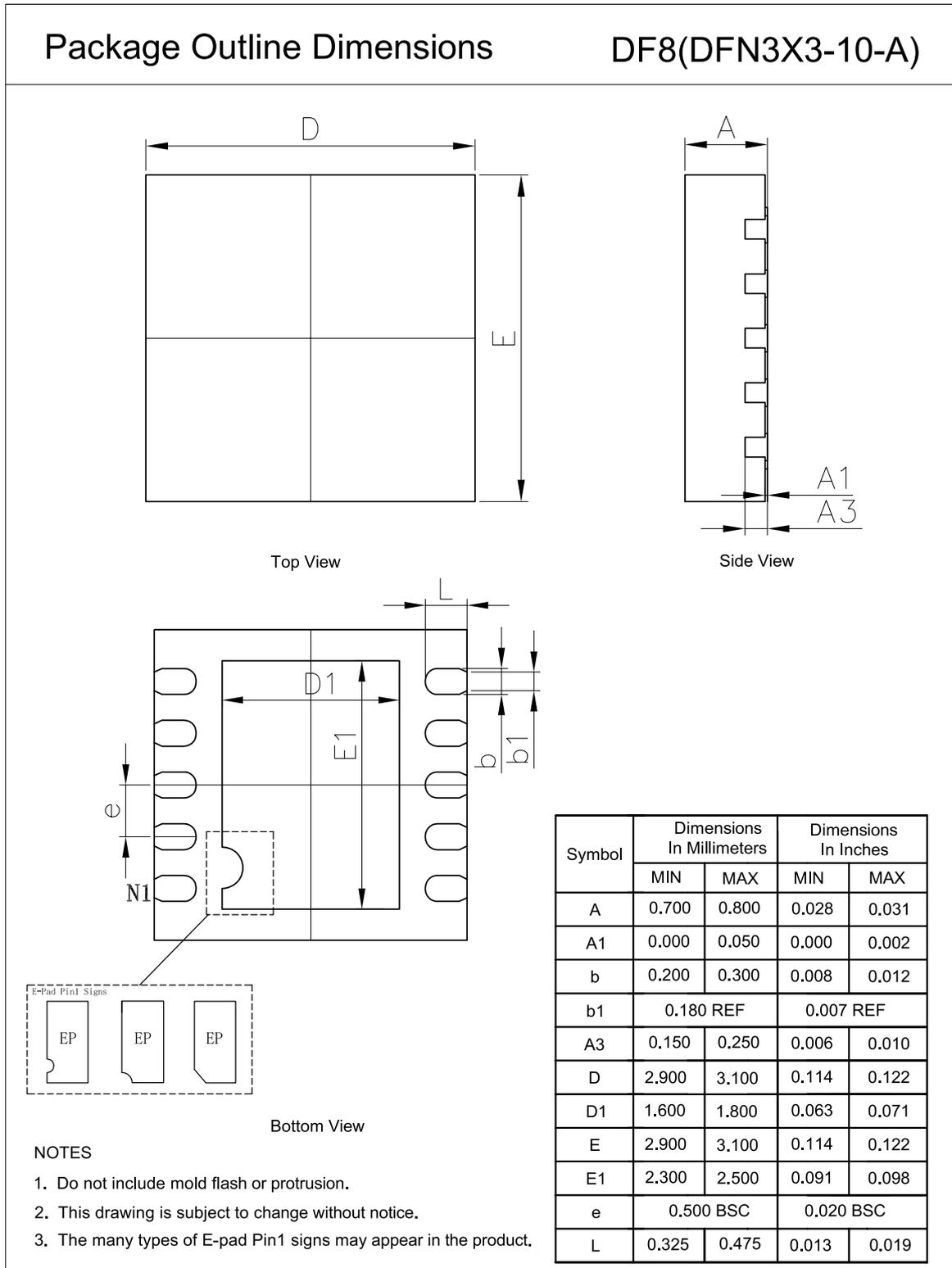
Tape and Reel Information



Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPL51200X-DF8R	DFN3x3-10	330	17.6	3.3	3.3	1.1	8	12	Q2

Package Outline Dimensions

DFN3X3-10



Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPL51200X-DF8R	-40 to 125°C	DFN3×3-10	L200X	3	4000	Green

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

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