HV, Bi-directional Current Sense Amplifier

Features

- Small Voltage Offset
  - TPA1295: ±100 μV (Max)
- Wide Common-Mode Voltage: −3.0 V to +70 V
- Wide CMRR through Common Voltage: 130 dB
- Supply Voltage: 3 V to 18 V
- Accuracy and Zero-Drift Performance
  - ±0.5% Gain Error (Max, −40°C to125°C)
  - 0.5-μV/°C Offset Drift (Max, −40°C to 125°C)
  - 5-ppm/°C Gain Drift (Max, −40°C to 125°C)
- Three Gain Options for Voltage Output
  - TPA1295T: 20 V/V
  - TPA1295F: 50 V/V
  - TPA1295H: 100 V/V

Applications

- Current Sensing (High-Side/Low-Side)
- Battery Chargers and Power Management
- Automotive
- Industrial Control and Automation
- Base Stations and Telecom Equipment

Description

The TPA1295 is a series of high-voltage, Bi-directional current sense amplifiers with voltage output. The TPA1295 can sense drops across shunts at common-mode voltages from −0.3 V to 70 V. The TPA1295 is available with three output voltage scales: 20 V/V, 50 V/V, and 100 V/V, with up to 500-kHz bandwidth.

The TPA1295 operates from single 3-V to 18-V supply, and offers breakthrough performance throughout the temperature range from −40°C to +125°C. It features a zero-drift core, which leads to a typical offset drift of 0.4 μV/°C throughout the operating temperature range and the common-mode voltage range.

The TPA1295 series is offered in the SOP8 package.

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Revision History

Date	Revision	Notes
2019-10-15	Rev.Pre.0	Initial version
2020-12-11	Rev.A.0	Released version
2022-05-01	Rev.A.1	Updated Order Information and Package Outline Dimensions
2024-12-17	Rev.A.2	The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged. • Updated to a new datasheet format. • Added the MSL value in the Order Information. • Updated the Tape and Reel Information.

Pin Configuration and Functions

TPA1295
SOP8
Top View

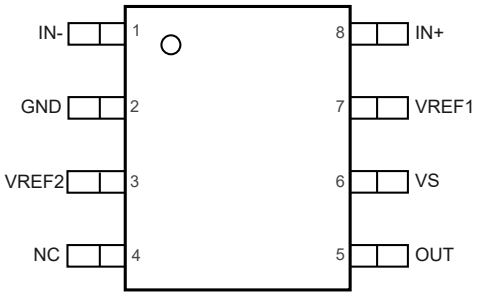


Table 1. Pin Functions: TPA1295

Pin		Description
No.	Name	
1	IN−	Negative input
2	GND	Ground
3	V_{REF2}	Reference input 2
4	NC	Not connected
5	OUT	Output
6	V_S	Power supply
7	V_{REF1}	Reference input 1
8	IN+	Positive input

Specifications

Absolute Maximum Ratings (1)

Symbol	Parameter	Min	Max	Unit
	Supply Voltage		18	V
	Input Common Voltage (Continuous)	−0.3	75	V
	Input Current: +IN, –IN (2)	−10	10	mA
T_A	Operating Temperature Range	−40	125	°C
T_J	Maximum Junction Temperature		150	°C
T_{STG}	Storage Temperature Range	−65	150	°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) The inputs are protected by ESD protection diodes to the power supply.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 (1)	2	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 (2)	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.

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOP8	158	43	°C/W

Electrical Characteristics

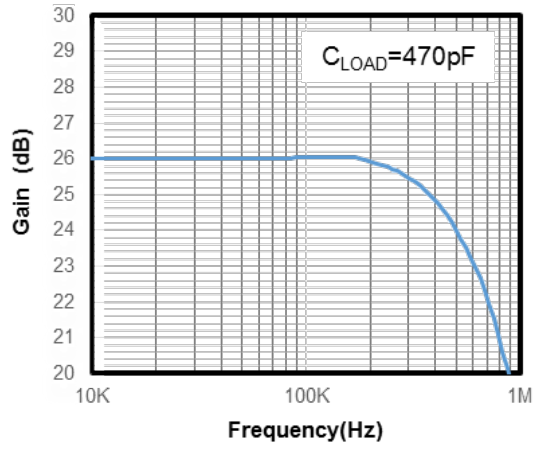
All test conditions: V_{CC} = 4.5 V to 5.5 V, V_{IO} = 3.0 V to 5.5 V, T_A = −40°C to 125°C, unless otherwise noted.

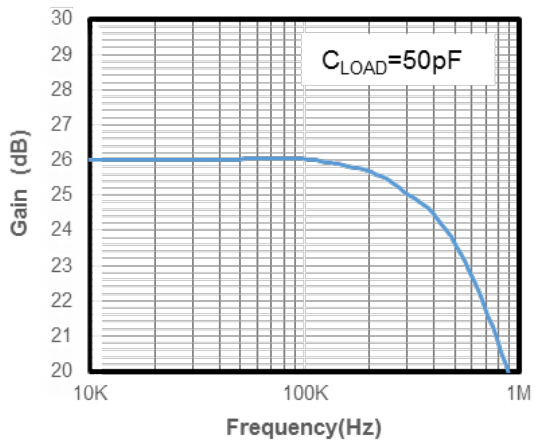
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Input						
V_{OS}	Input Offset Voltage			±10	±100	μV
V_{OS} TC (1)	Input Offset Voltage Drift	−40°C to 125°C			0.5	μV/°C
V_{CM}	Common-Mode Input Range	−40°C to 125°C	−0.1		70	V
CMRR	Common-Mode Rejection Ratio	−40°C to 125°C, −0.3 V < (+V_S) < 70 V	110	130		dB
		DC to 50 kHz		90		dB
I_B	Input Bias Current	−40°C to 125°C, V_{CM} = 12 V		12		μA
		−40°C to 125°C, V_{CM} = 70 V			210	μA
I_{OS}	Input Offset Current	−40°C to 125°C			1	μA
PSRR	Power Supply Rejection Ratio	3.0 V < (+V_S) < 5.5 V		110		dB
Noise RTI (2)						
e_n	Input Voltage Noise Density	f = 1 kHz		55		nV/√Hz
Output						
G	Gain	TPA1295T		20		V/V
		TPA1295F		50		V/V
		TPA1295H		100		V/V
GE	Gain Error	−40°C to 125°C		±0.1	±0.5	%
GE TC	Gain Error vs. Temperature	−40°C to 125°C		3	5	ppm
C_{LOAD}	Maxim Capacitive Load	No oscillation		0.5		nF
V_{OH}	Output Swing from Supply Rail	−40°C to 125°C, Source 500 μA		0.1	0.31	V
V_{OL}	Output Swing from Supply Rail	−40°C to 125°C, Sink 500 μA		0.01	0.02	V
Frequence Response						
BW	Bandwidth	All gain configuration		500		kHz
SR	Slew Rate	V_{SENSE} = V_{IN+} – V_{IN-} = 500 mV		20		V/μs
Power Supply						
+V_S	Supply Voltage		3		18	V
I_Q	Quiescent Current			600	1000	μA
Temperature Range						
	Specified Range		−40		125	°C

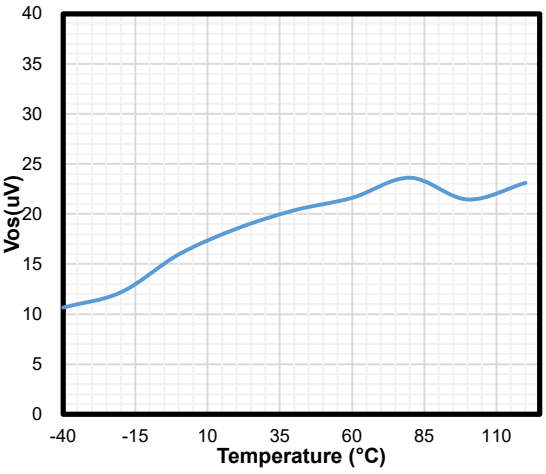
(1) Maxim specification is calculated with a limited sample quantity in the laboratory.
(2) RTI = referred to input.

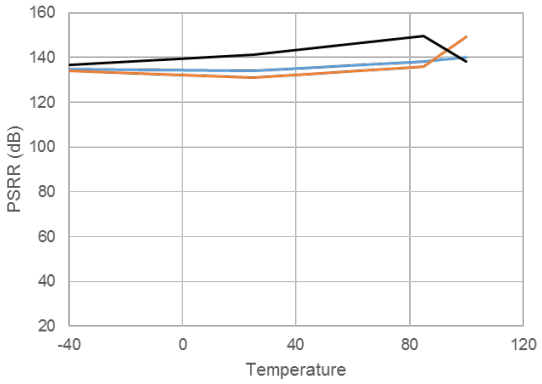
Typical Performance Characteristics

All test conditions: T_A = 25°C, V_{SENSE} = V_{IN+} – V_{IN-} = 1 mV, V_S = 12 V, V_{IN+} = 24 V, unless otherwise noted.

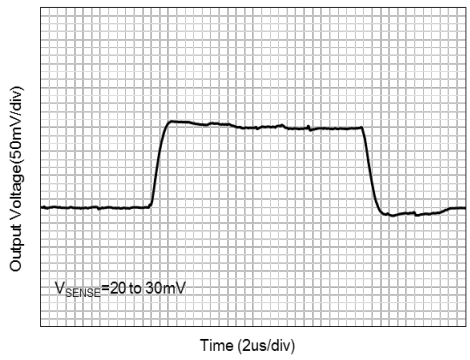




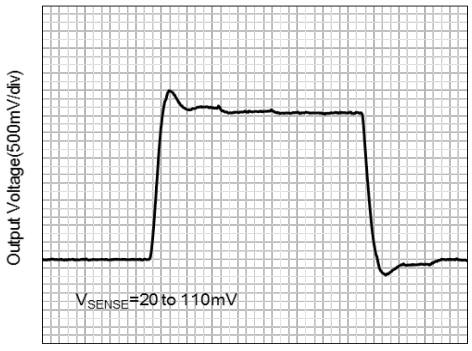




PSRR Vs Temperature

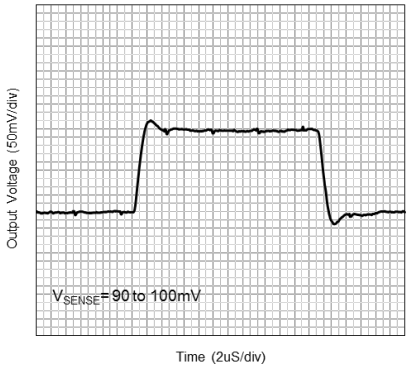


STEP RESPONSE

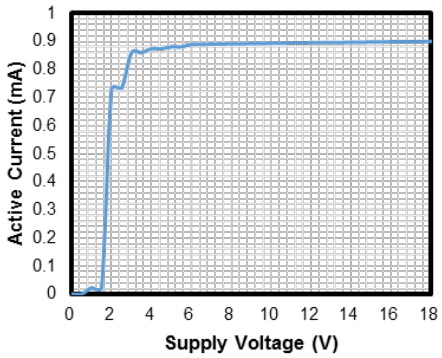


STEP RESPONSE

Typical Performance Characteristics (Continued)



STEP RESPONSE



Detailed Description

Overview

The TPA1295 is a series of high-voltage power-supply, zero-drift, difference amplifiers that use a unique architecture to accurately amplify small differential current shunt voltages, especially for fast changing common-mode voltages. In typical applications, the TPA1295 series measures current by amplifying the voltage across a shunt resistor connected to its inputs by 3 gains of 20 V/V, 50 V/V, and 100 V/V. The design provides excellent common-mode rejection, even with PWM common-mode inputs that can change at very fast rates. The TPA1295 features an input offset less than 100 μV, and an offset drift of less than 400 nV/°C.

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

Reference Pin Connection for Bi-directional and Unidirectional Current Measurements

The output voltage is set by applying a voltage to the reference voltage inputs, REF1 and REF2. The output of the TPA1295 can be adjusted for unidirectional or bidirectional operation. In unidirectional operation, the output can be set at the negative rail (near ground) or at the positive rail (near V_S) when the differential input is 0 V, and both reference inputs are connected to ground or positive supply. In bi-directional operation, the output is set within the output range. Adjusting the output is accomplished by applying voltage(s) to the referenced inputs, V_{REF1} and V_{REF2}. The output when there is no differential input can be calculated by Equation 1.

$$V_{out} = (V_{REF1} + V_{REF2}) \times 5/12 \quad (1)$$

Selecting R_{sense}

The zero-drift offset performance of the TPA1295 offers several benefits. Most often, the primary advantage of the low offset characteristic enables lower full-scale drops across the R_{sense}. For example, non-zero-drift current sense monitors typically require a full-scale range of 100 mV. The TPA1295 family gives equivalent accuracy at a full-scale range from approximately 5 to 10 mV. This accuracy reduces R_{sense} dissipation by an order of magnitude with many additional benefits.

Alternatively, there are applications that must measure current over a wide dynamic range that can take advantage of the low offset at the low end of the measurement. Most often, these applications can use the lower gains of the TPA1295 to accommodate larger R_{sense} drops at the upper end of the scale.

Recommended Component Values

Ideally, the maximum load current develops the full-scale sense voltage across the current-sense resistor. Choose the gain needed to match the maximum output voltage required for the application:

$$V_{out} = V_{sense} \times A_V \quad (2)$$

Where V_{sense} is the full-scale sense voltage, and A_V is the gain of the TPA1285.

In applications of monitoring a high current, ensure that R_{sense} is able to dissipate its own I^2R power loss. If the power dissipation of the resistor exceeds the nominal value, its value may drift, or it may fail altogether. The TPA1295 senses a wide variety of currents with different sense-resistor values.

Power Supply Recommendation

The input circuitry of the TP1295 can accurately measure beyond its power-supply voltage, $+V_S$. For example, the $+V_S$ power supply can be 5 V, whereas the load power-supply voltage can be as high as 70 V. However, the output voltage range of the OUT pin is limited by the voltages on the power-supply pin.

Typical Application

Figure 1 shows the typical application schematic.

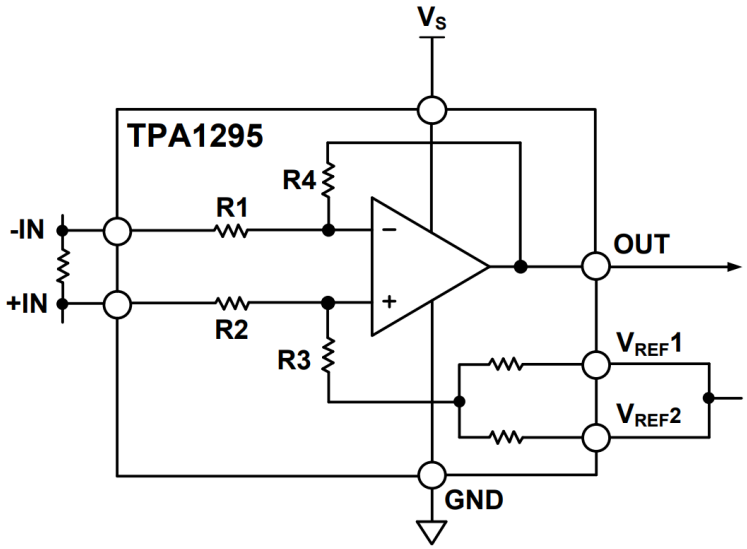


Figure 1. Typical Application Circuit

Layout

Layout Guideline

Keep the traces of external capacitors as short as possible, and help the C1 and C2 nodes have the fastest rise-and-fall time.

Layout Example

Figure 2 shows the location of external components as they appear on the PCB diagram.

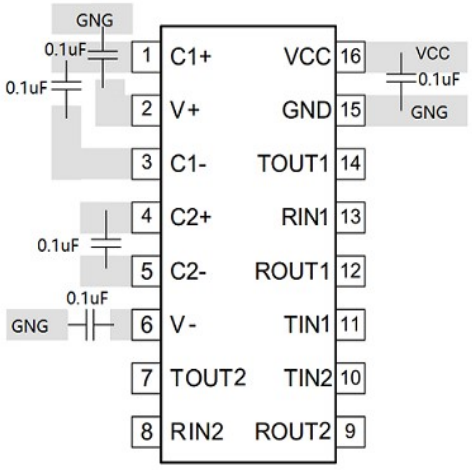
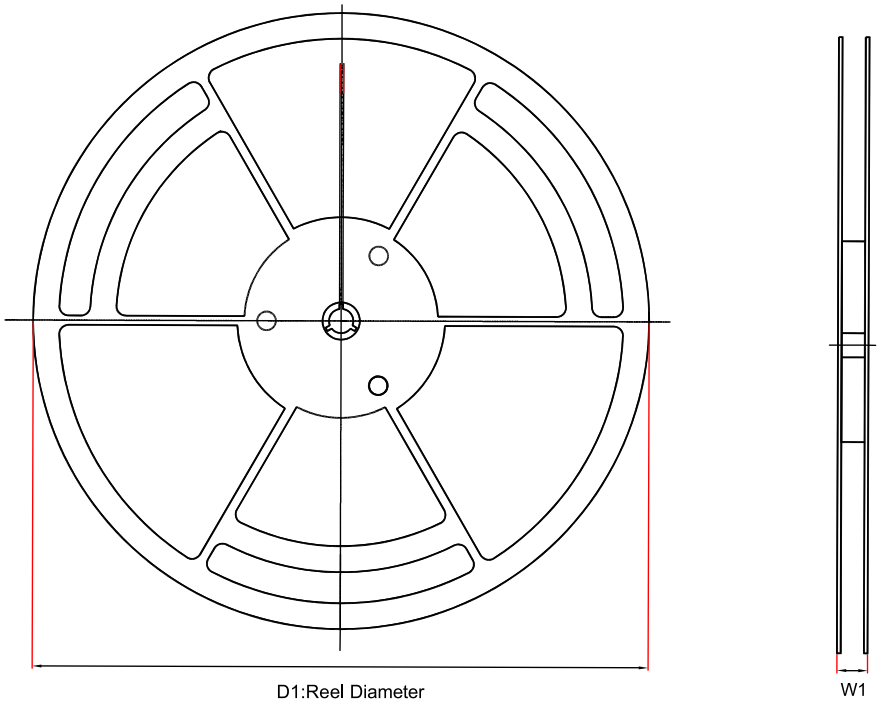
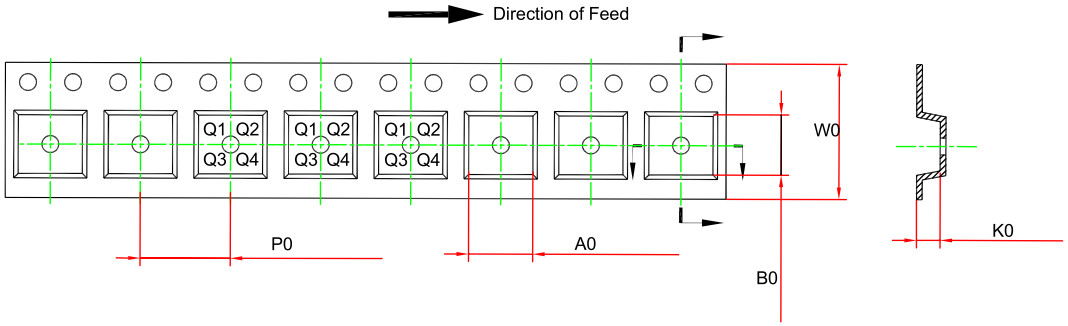


Figure 2. Layout Example Diagram

Tape and Reel Information





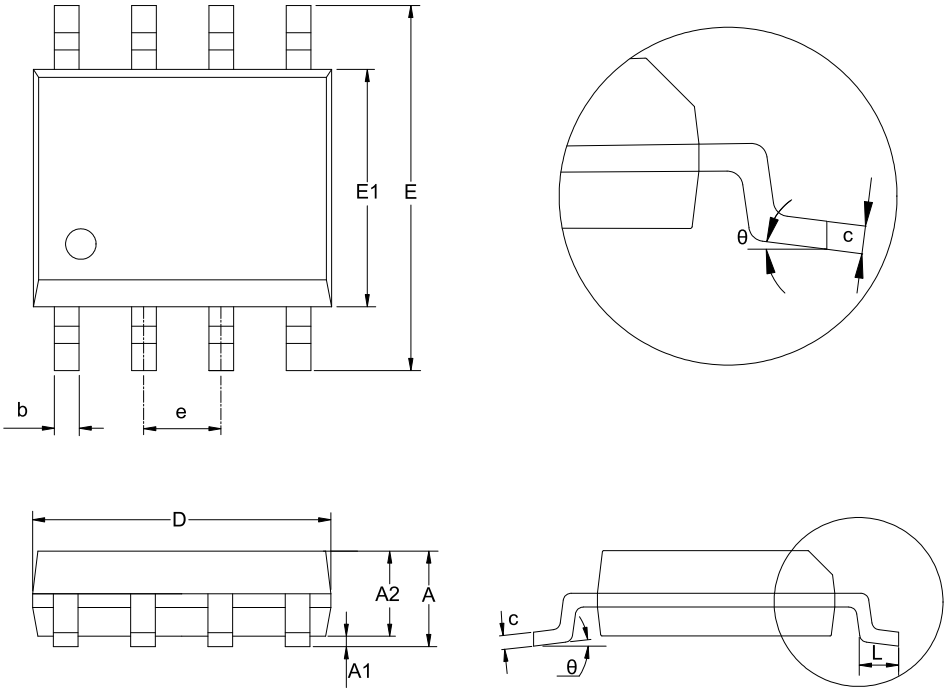
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) (1)	B0 (mm) (1)	K0 (mm) (1)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA1295T-SO1R-S	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA1295F-SO1R-S	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA1295H-SO1R-S	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1

(1) The value is for reference only. Contact the 3PEAK factory for more information.

Package Outline Dimensions

SOP8

Package Outline Dimensions SO1(SOP-8-B)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.000	0.016	0.039
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

Order Information

Order Number	Operating Temperature Range	Gain	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPA1295T-SO1R-S (1)	–40°C to 125°C	20 V/V	SOP8	295T	3	Tape and Reel, 4,000	Green
TPA1295F-SO1R-S	–40°C to 125°C	50 V/V	SOP8	295F	3	Tape and Reel, 4,000	Green
TPA1295H-SO1R-S (1)	–40°C to 125°C	100 V/V	SOP8	295H	3	Tape and Reel, 4,000	Green

(1) For future products, contact the 3PEAK factory for more information and samples.

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

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