High-Voltage, Precision, Zero-drift, Instrumentation Amplifier

Features

- Excellent DC Specifications
  - Small Voltage Offset: ±50 μV (Max)
  - Small Voltage Offset Drift: 0.2 μV/°C (Max)
  - Small Input Bias Current: 1.5 nA (Max)
- Excellent AC Specifications
  - CMRR: 80 dB @ G = 1 (Min)
  - Small Input Noise: 15 nV/$\sqrt{Hz}$ @ G=10
  - Input Noise (0.1 Hz to 10 Hz): 1 μV p-p
  - −3dB Bandwidth: 1.6 MHz
  - Slew Rate: 5 V/μs
- Gain Set with 1 External Resistor (Gain Range 1 to 1,000)
- Supply Voltage: ±2 V to ±18 V
- Rail-to-Rail for Voltage Output
- Operating Temperature: –45°C to +125°C
- SOP8, MSOP8, and DFN3X3-8 Packages

Applications

- Weigh Scales for Bridge Amplifiers
- Medical and ECG Amplifiers
- Industrial Process Control
- Precision Data Acquisition System
- Pressure Sensors
- Precision Current Measurement

Description

The TPA1286 is a low-cost, wide supply range instrumentation amplifier that requires only one external resistor to set any gain between 1 and 1,000. The TPA1286 is designed to work with a variety of single voltages. A wide input range and rail-to-rail output allow the signal to fully use the supply rails. Low voltage offset, low offset drift, low gain drift, high gain accuracy, and high CMRR make this part an excellent choice in applications that demand the best DC performance.

The TPA1286 operates from a single 4-V to 36-V supply, and offers breakthrough performance throughout the −40°C to +125°C temperature range. It features a zero-drift core, which leads to a typical offset drift of 0.2 μV/°C throughout the operating temperature range.

The TPA1286 is available in SOP8, MSOP8, and DFN3X3-8 packages.

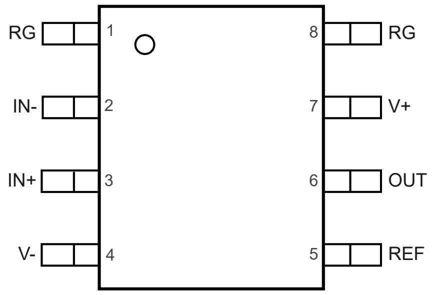
Table of Contents

Revision History

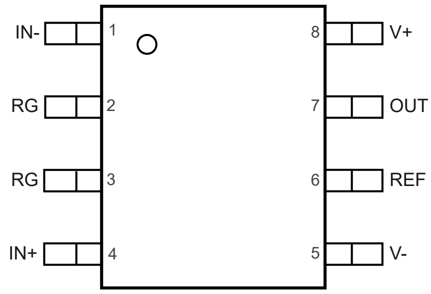
Date	Revision	Notes
2020-02-05	Rev.Pre.0	Initial version
2020-12-25	Rev.A.0	Released version
2021-03-30	Rev.A.1	Added DFN3X3-8 package
2022-05-01	Rev.A.2	Updated package outline dimensions
2024-01-11	Rev.A.3	Added Figure 31 to Figure 38: Input Common-Mode Range vs. Output Voltage.
2025-04-11	Rev.A.4	Corrected handwriting errors. Updated the value of "Input Voltage" in "Absolute Maximum Rating" from "(V-) – 0.3 to (V+) + 0.3 V " to "(V-) – 0.3 to 40 V "

Pin Configuration and Functions

TPA1286
SOP8/MSOP8 Package
Top View



TPA1286U
SOP8/MSOP8 Package
Top View



TPA1286
DFN3X3-8 Package
Top View

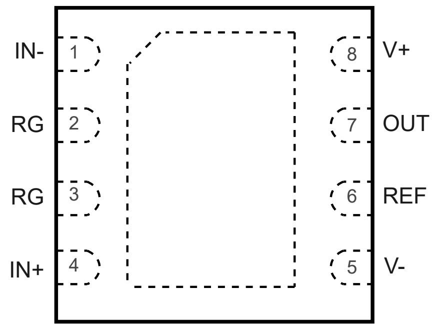


Table 1. Pin Functions: TPA1286

Pin			Name	I/O	Description
TPA1286	TPA1286U	DFN3X3-8			
2	1	1	IN-		Negative Input
3	4	4	IN+		Positive Input
1, 8	2, 3	2,3	RG		Gain setting
5	6	6	REF		Reference Input
6	7	7	OUT		Output
7	8	8	V+		Positive power supply
4	5	5	V-		Negative power supply
-	-	Thermal pad	Thermal pad		Exposed thermal die pad is internally connected to –Vs. Connect externally to –Vs or leave floating

Specifications

Absolute Maximum Ratings [1]

Parameters	Min	Max	Unit
Supply Voltage，(V+) - (V-)		40	V
Input Voltages	(V-) − 0.3	40	V
Differential Input Voltage		infinite	V
Input Current: IN+, IN- [2]	−10	+10	mA
Operating Temperature Range	−40	125	℃
Maximum Working Junction Temperature		150	℃
Storage Temperature Range	−65	150	℃
Lead Temperature (Soldering, 10 sec)		260	℃

(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]	3	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 Resistance

Package Type	θ_{JA}	θ_{JC}	Unit
SOP8	158	43	°C/W
MSOP8	210	45	°C/W
DFN3X3-8	51	60	°C/W

Electrical Characteristics

All test conditions: T_A = 25°C, V+ = +15 V, V- = −15 V, REF = 0 V, unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
Power Supply						
V_{OSI}	Input Stage Offset Voltage	At RTI		±10	±50	μV
		At RTI, −40°C to 125°C		±0.1	±0.2	μV/°C
V_{OSO}	Output Stage Offset Voltage	At RTI		±100	±300	μV
		At RTI, −40°C to 125°C		±0.2	±0.3	μV/°C
V_{OS}	Offset Voltage	At RTI		±10 ±100/G	±50 ±300/G	μV
V_{OS} TC	Input Offset Voltage Drift	−40°C to 125°C			±0.2 ±0.3/G	μV/°C
V_{CM}	Common-Mode Input Range	−40°C to 125°C	(V-) +0.1		(V+) - 1.5	V
CMRR	Common Mode Rejection Ratio	CMRR at DC, G = 1	80	100		dB
		CMRR at DC, G = 10	100	120		dB
		CMRR at DC, G = 100	110	130		
		CMRR at DC, G = 1000	120	140		
I_B	Input Bias Current			0.3	1.5	nA
		−40°C to 125°C		10		pA/°C
I_{OS}	Input Offset Current			0.3	1.5	nA
		−40°C to 125°C		10		pA/°C
Input Impedance	Input Impedance	Differential		57||6		GΩ||pF
		Common Mode		44||14		GΩ||pF
PSRR	Power Supply Rejection Ratio	G = 1	100	120		dB
		G = 10	110	130		dB
		G = 100	120	138		dB
		G = 1000	130	140		dB
RIN	Reference Input			20		kΩ
Noise RTI						
e_n	Input Voltage Noise Density	f = 1 kHz, G = 10		15		nV/√Hz
		f = 0.1 Hz to 10 Hz, G = 1		1		μV p-p
Output						
G	G = 1 + (49.4 kΩ/RG)		1		1000	V/V
GE	Gain Error	G = 1		±0.01%	±0.05%	
		G = 10		±0.1%	±0.15%	
		G = 100		±0.1%	±0.2%	

Parameter		Conditions	Min	Typ	Max	Unit
		G = 1000		±0.3%	±0.6%	
G TC	Gain vs. Temperature	−40°C to 125°C, G = 1		1	5	ppm/°C
I_{SC}	Short Circuit Current	−40°C to 125°C		±70		mA
V_{OH}	Output Swing from Supply Rail	−40°C to 125°C, R_L = 10 kΩ		0.12	0.2	V
V_{OL}	Output Swing from Supply Rail	−40°C to 125°C, R_L = 10 kΩ		0.05	0.1	V
Frequency Response						
BW	−3dB Bandwidth	G = 1		1600		kHz
		G = 10		400		kHz
		G = 100		100		kHz
		G = 1000		11		kHz
ST	Setting time to 0.01%	G = 1		2.1		μs
SR	Slew Rate	G = 1		5		V/μs
		G = 100		2.5		V/μs
Power Supply						
V+	Supply Voltage		±2		±18	V
I_Q	Quiescent Current			3.8	4.5	mA
Temperature Range						
Specified Range			−40		125	°C

Typical Performance Characteristics

All test conditions: T_A = 25°C, Vs = ±15 V, RL = 10 kΩ, unless otherwise noted.

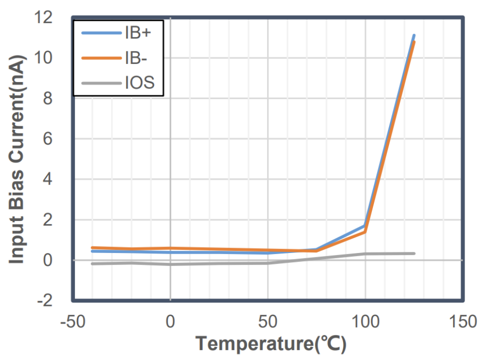


Figure 1. IB vs. Temperature

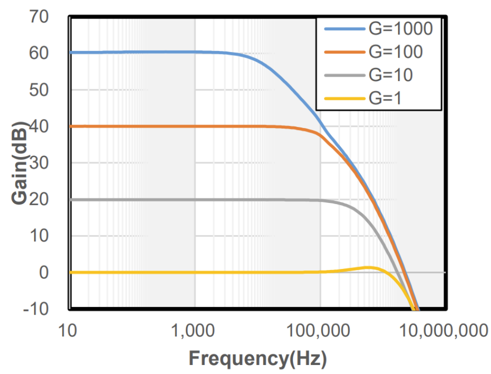


Figure 2. Gain vs. Frequency

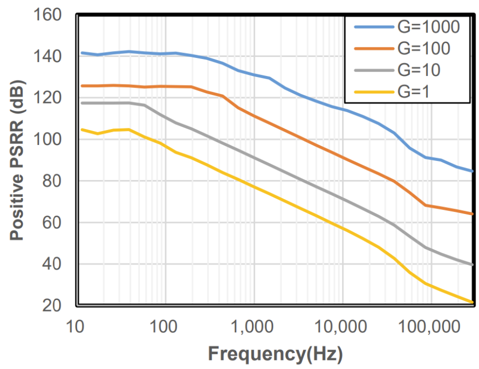


Figure 3. Positive PSRR vs. Frequency

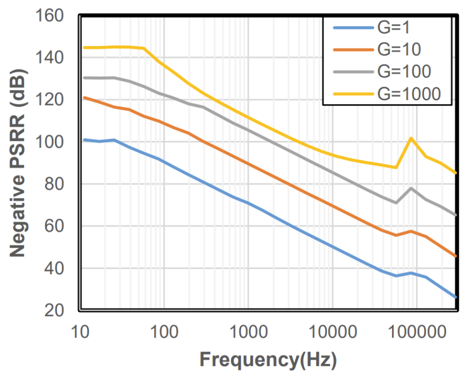


Figure 4. Negative PSRR vs. Frequency

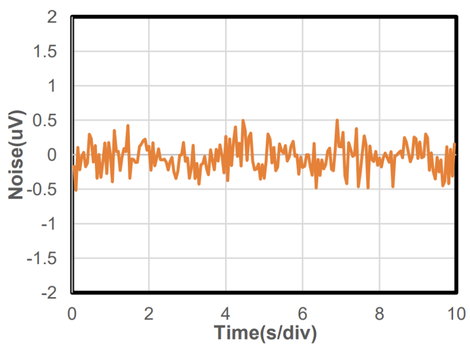


Figure 5. 0.1-Hz to 10-Hz RTI Noise

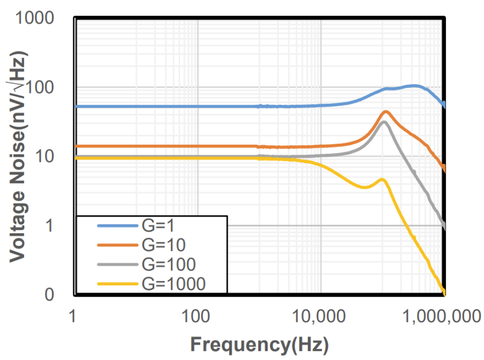


Figure 6. Noise Density vs. Frequency

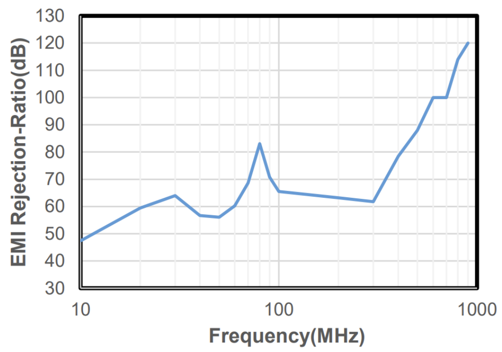


Figure 7. EMIRR

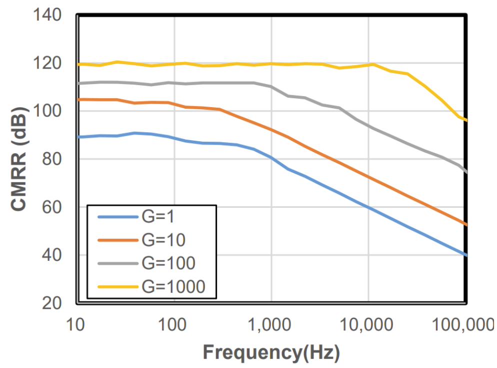


Figure 8. CMRR vs. Frequency

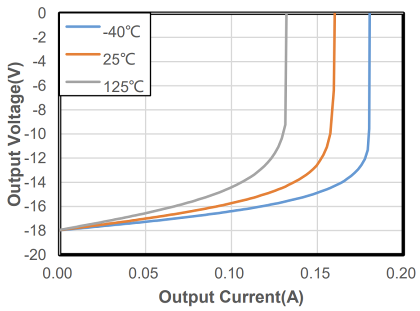


Figure 9. Negative Output Voltage Swing vs. Output Voltage

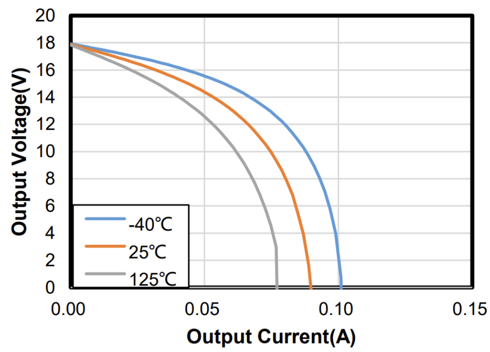


Figure 10. Positive Output Voltage Swing vs. Output Voltage

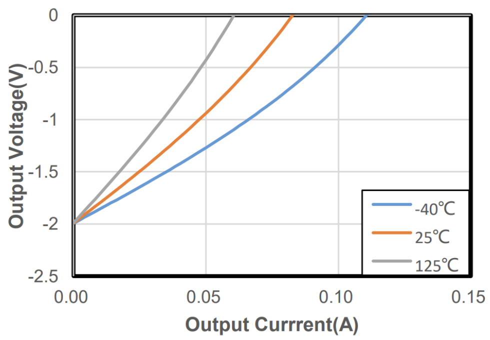


Figure 11. Negative Output Voltage Swing vs. Output Voltage

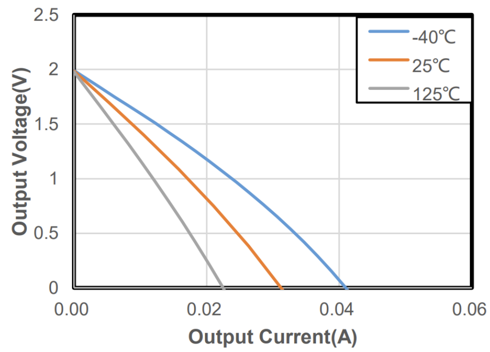


Figure 12. Positive Output Voltage Swing vs. Output Voltage

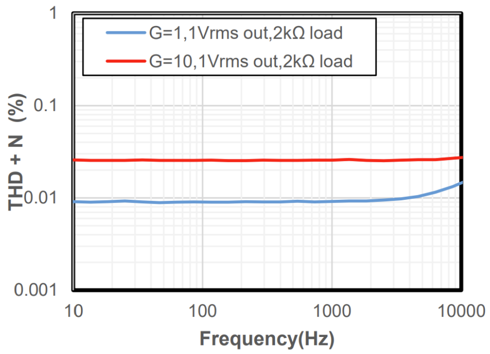


Figure 13. THD + N vs. Frequency

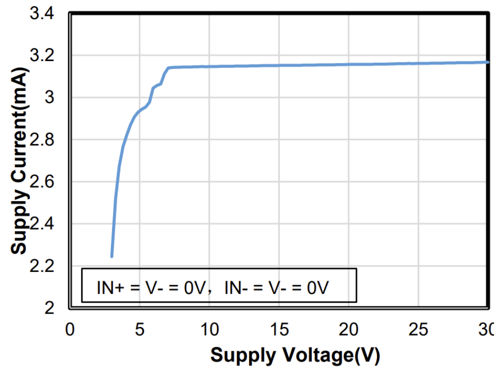


Figure 14. Supply Current vs. Voltage

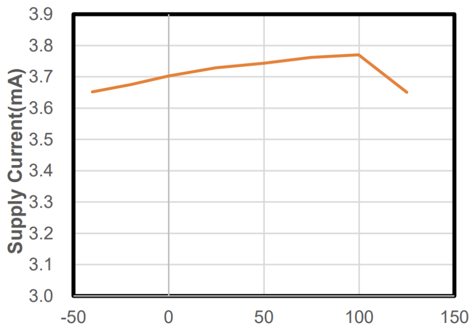


Figure 15. Supply Current vs. Temp

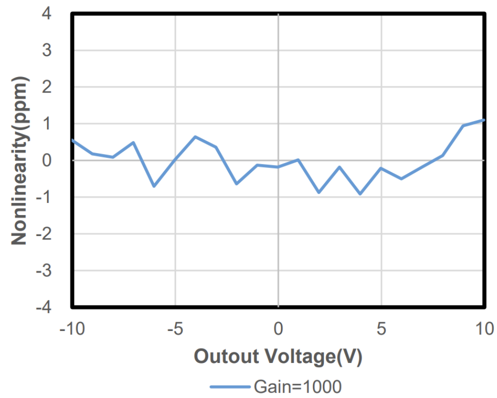


Figure 16. Gain Nonlineraity

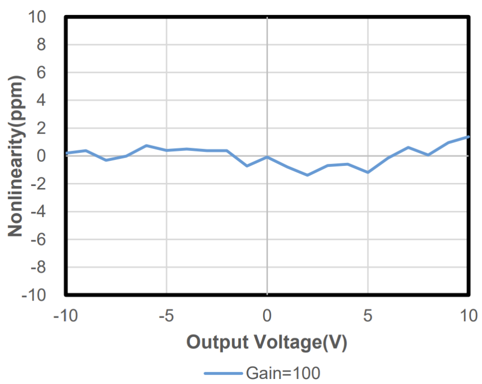


Figure 17. Gain Nonlinearity

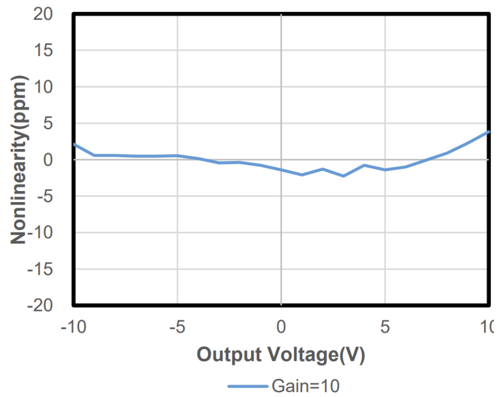


Figure 18. Gain Nonlinearity

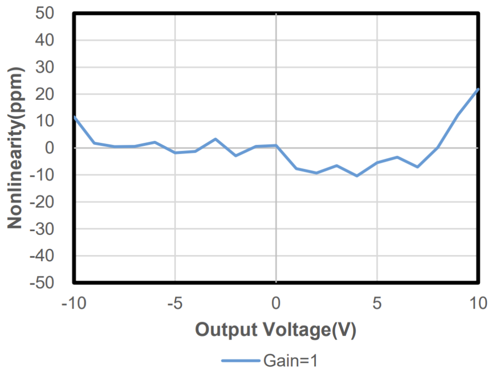


Figure 19. Gain Nonlinearity

Voltage: 2 V/div for Output, Time: 10 us/div G = 1,

V_{REF} = GND; V_{IN} = 10V_{PP}, Load R = 10 K

Figure 20. Slew Rate

Voltage: 5 V/div for Output, Time: 2 us/div G = 10,

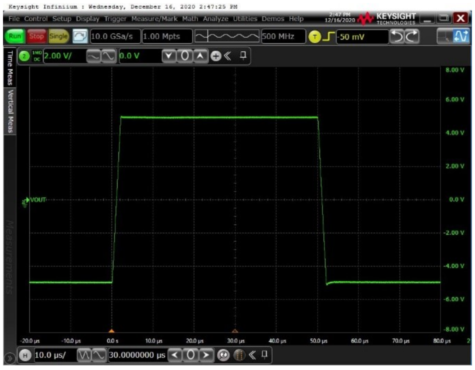
V_{REF} = GND; V_{IN} = 10V_{PP}, Load R = 10 K, C = 100 pF

Figure 21. Positive Overload Recovery

Voltage: 5 V/div for Output, Time: 2 us/div G = 10,

V_{REF} = GND; V_{IN} = 10V_{PP}, Load R = 10 K, C = 100 pF

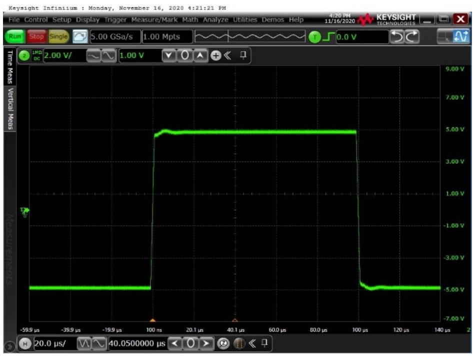
Figure 22. Negative Overload Recovery



Voltage: 2 V/div for Output, Time: 10 us/div G = 1,

V_{REF} = GND; V_{IN} = 10V_{PP}, Load R = 10 K, C = 100 pF

Figure 23. Large-Signal Pulse Response



Voltage: 2 V/div for Output, Time: 20 us/div G = 10,

V_{REF} = GND; V_{IN} = 1V_{PP}, Load R = 10 K, C = 100 pF

Figure 24. Large-Signal Pulse Response

Voltage: 2 V/div for Output, Time: 20 us/div G=100,

VREF = GND; VIN=0.1 VPP, Load R=10 K C=100 pF

Figure 25. Large-Signal Pulse Response

Voltage: 2 V/div for Output, Time: 50 us/div G=1000,

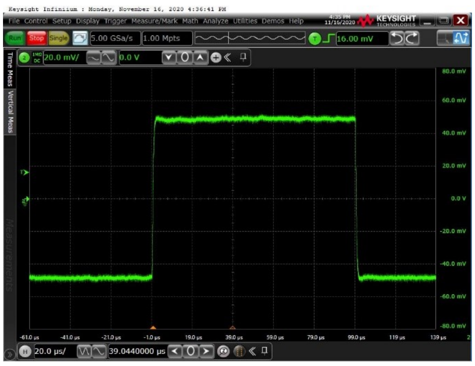
VREF = GND; VIN=10 mVPP, Load R=10 K C=100 pF

Figure 26. Large-Signal Pulse Response

Voltage: 25 mV/div for Output, Time: 10 us/div G=1,

VREF = GND; VIN=100 mVPP, Load R=10 K C=100 pF

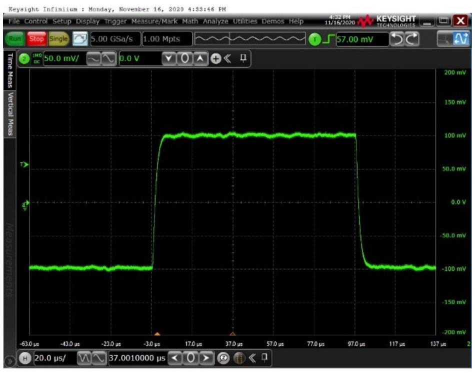
Figure 27. Small-Signal Pulse Response



Voltage: 20m V/div for Output, Time: 20 us/div G=10,

VREF = GND; VIN=10 mVPP, Load R=10 K C=100 pF

Figure 28. Small-Signal Pulse Response



Voltage: 50 mV/div for Output, Time: 20 us/div G=100,

VREF = GND; VIN=2 mVPP, Load R=10 K C=100 pF

Figure 29. Small-Signal Pulse Response

Voltage: 500 mV/div for Output, Time: 50 us/div G=10,

VREF = GND; VIN=2 mVPP, Load R=10 K C=100 pF

Figure 30. Small-Signal Pulse Response

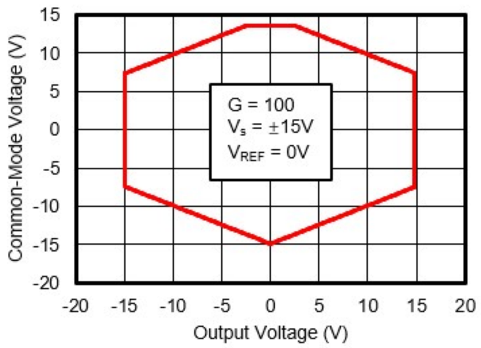


Figure 31. Input Common-Mode Range vs. Output Voltage

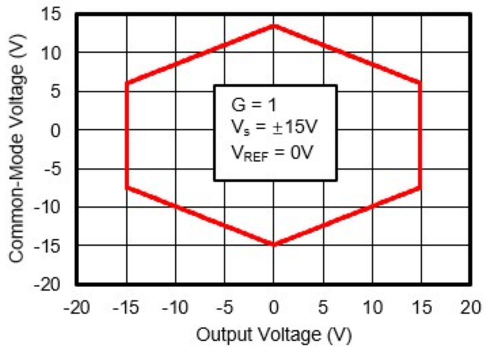


Figure 32. Input Common-Mode Range vs. Output Voltage

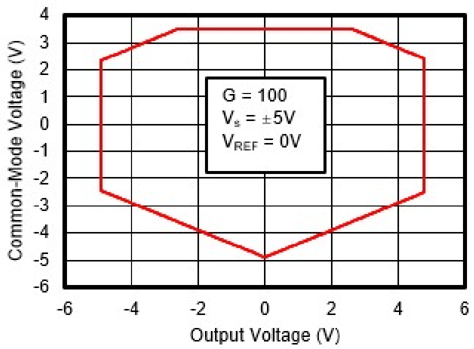


Figure 33. Input Common-Mode Range vs. Output Voltage

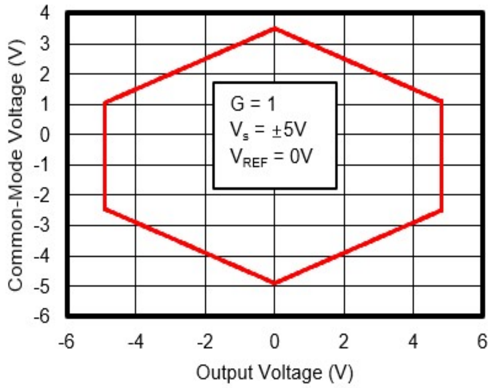


Figure 34. Input Common-Mode Range vs. Output Voltage

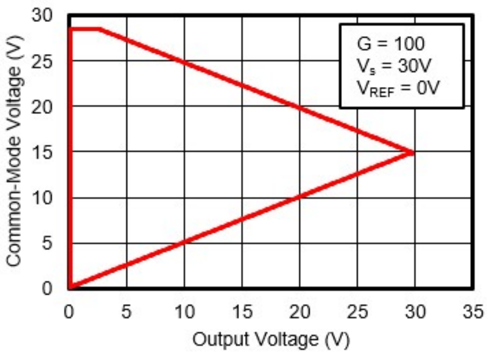


Figure 35. Input Common-Mode Range vs. Output Voltage

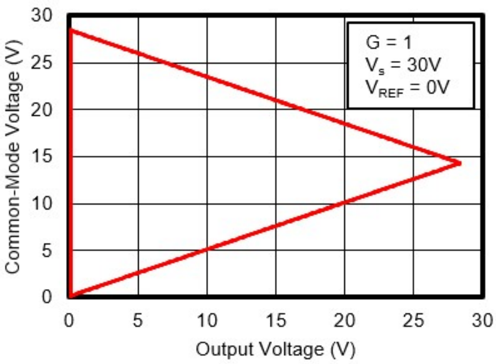


Figure 36. Input Common-Mode Range vs. Output Voltage

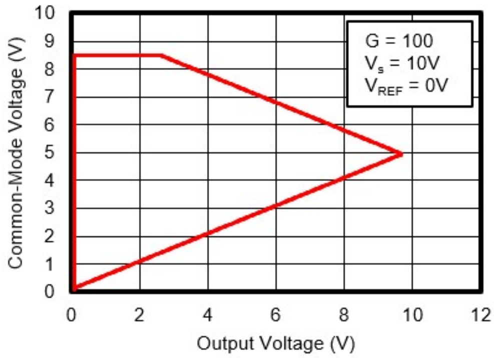


Figure 37. Input Common-Mode Range vs. Output Voltage

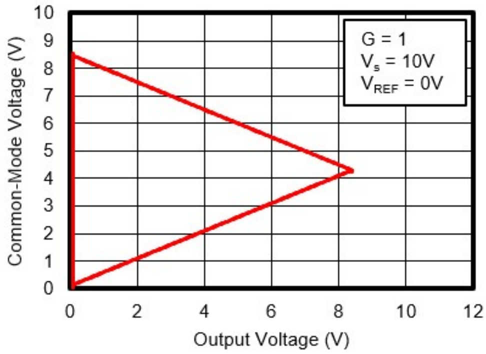


Figure 38. Input Common-Mode Range vs. Output Voltage

Detailed Description

Overview

The TPA1286 is a monolithic instrumentation amplifier (INA) based on the high-voltage, precision zero-drift OPA core, and classic 3-op amp topology. The TPA1286 also integrates precision resistors to ensure excellent common-mode rejection and low gain error. The combination of the zero-drift amplifier core and the precision resistors allows this device to achieve outstanding DC precision and makes the TPA1286 ideal for many high-voltage industrial applications.

A unique pinout of the TPA1286U enables it to meet a good CMRR specification. The balanced pinout reduces the parasitic that has adversely affected CMRR performance. In addition, this pinout simplifies the board layout because associated traces are grouped together. For example, the gain setting resistor pins are adjacent to the inputs, and the reference pin is next to the output.

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.

Operation Overview

The TPA1286 is a monolithic instrumentation amplifier (INA) based on the high-voltage, precision zero-drift OPA core, and classic 3-op amp topology. The TPA1286 also integrates precision resistors to ensure excellent common-mode rejection and low gain error. The combination of the zero-drift amplifier core and the precision resistors allows this device to achieve outstanding DC precision and makes the TPA1286 ideal for many high-voltage industrial applications.

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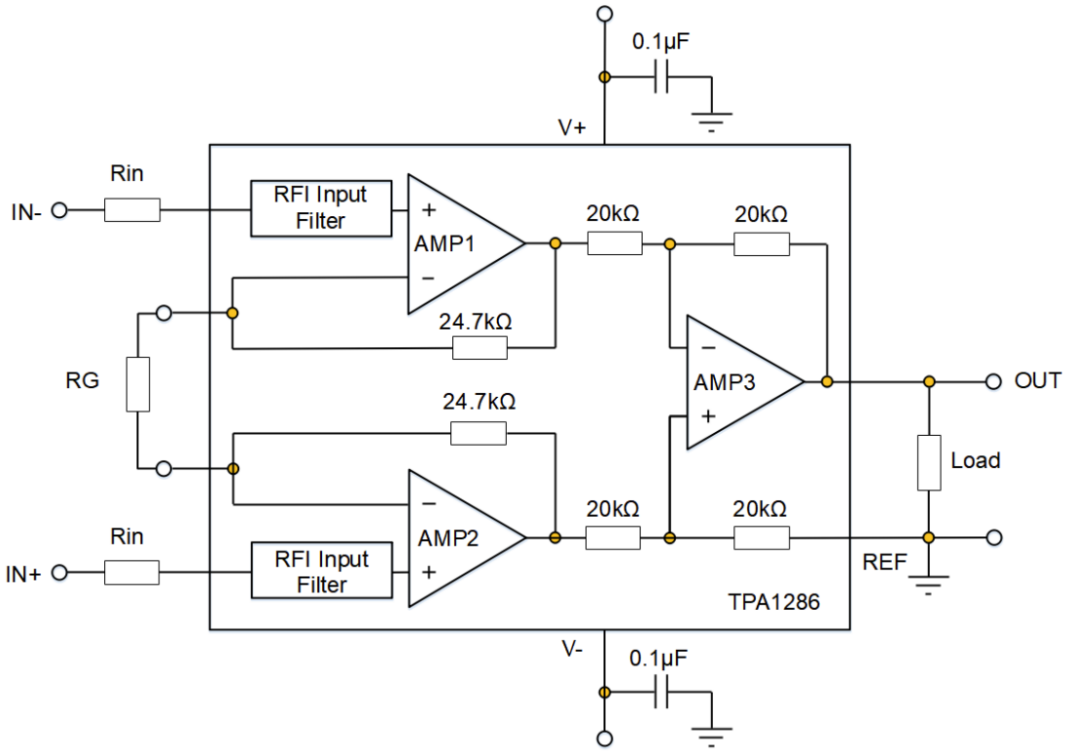
Application Information

TPA1286 Application Block Diagram



Selecting GAIN Resistor

The gain of the TPA1286 is set by a single external resistor, RG, connected between RG pins. The value of RG is selected according to the equation below. TPA1286 can be set as G = 1 when no gain resistor is used. Gain accuracy is determined by the accuracy of RG. The stability and temperature drift of the external gain setting resistor, RG, also affect gain. The contribution of RG to gain accuracy and drift can be determined from the equation below.

$$G = 1 + \frac{49.4k}{RG} \quad (1)$$

Reference Input Pin

As shown in the above Figure, the reference pin, REF, is connected with a 20 kΩ resistor. The output of the instrumentation amplifier is referenced to the voltage on the REF pin; this is useful when the output signal needs to be offset to a precise mid-supply level. For example, a voltage source can be tied to the REF pin to level-shift the output so that the TPA1286 can interface with an ADC. For best performance, source impedance to the REF pin should be kept as low as possible, because parasitic resistance can adversely affect CMRR and gain accuracy. PCB Layout should be very careful to tie REF to the appropriate local cleaning ground.

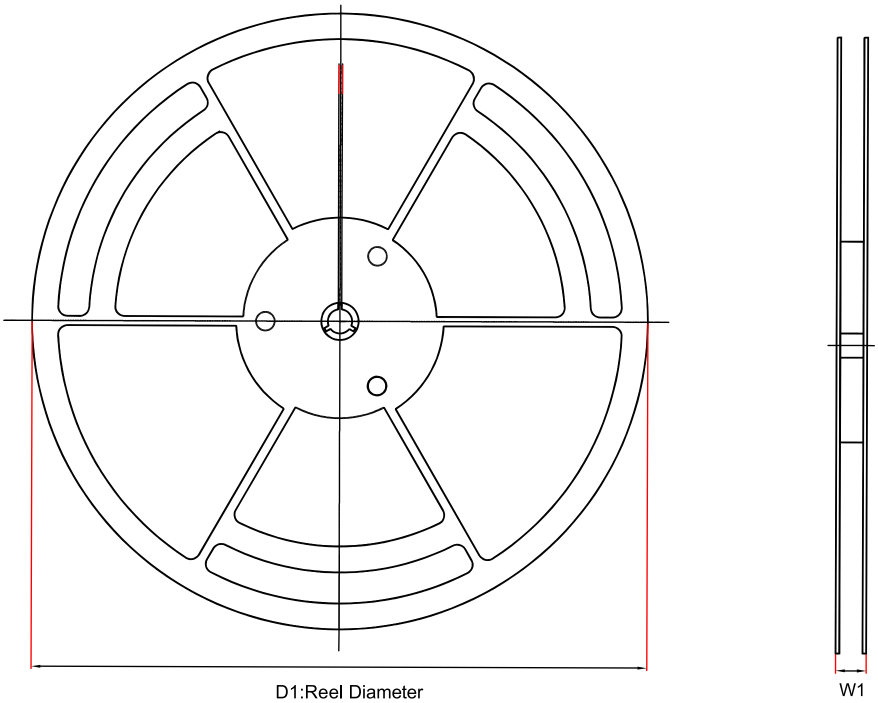
Power Supply Recommendation

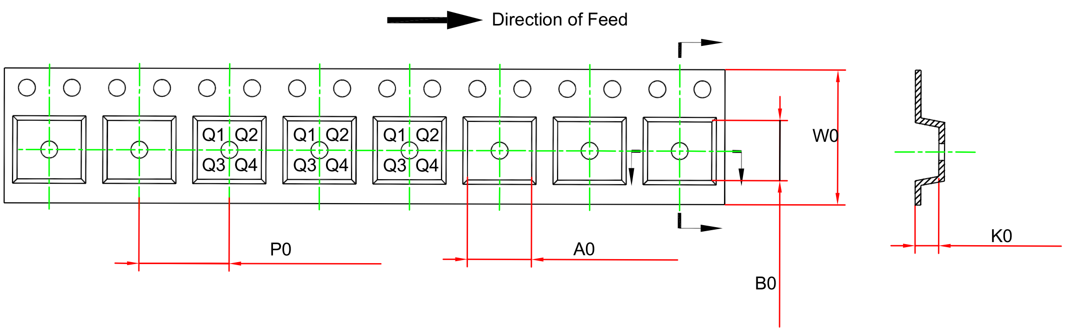
A stable and clean DC voltage should be used as the power supply of the instrumentation amplifier, which noise on the supply pins can affect performance. Bypass capacitors should be used to decouple the amplifier. A 0.1 μF capacitor should be placed close to each supply pin.

Proper Board Layout

To maximize system performance, careful board layout is needed. Traces from the gain setting resistor to the RG pins should be kept as short as possible to minimize parasitic inductance. To ensure the most accurate output, the trace from the REF pin should either be connected to the local ground of the TPA1286, or connected to a voltage that is referenced to the local ground of the TPA1286.

Tape and Reel Information



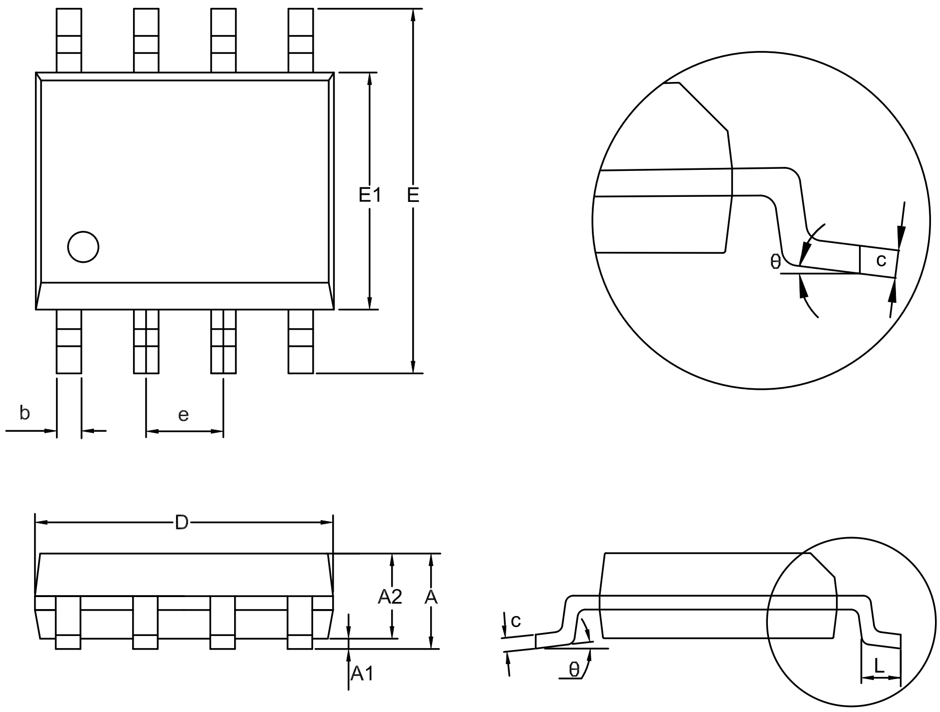


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA1286-SO1R	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA1286U-SO1R	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA1286-VS1R	MSOP8	330.0	17.6	5.2	3.3	1.5	8.0	12.0	Q1
TPA1286U-VS1R	MSOP8	330.0	17.6	5.2	3.3	1.5	8.0	12.0	Q1
TPA1286U-DF7R	DFN3X3-8	330.0	16.8	3.3	3.3	1.1	8.0	12.0	Q2

Package Outline Dimensions

SOP8

Package Outline Dimensions SO1(SOP-8-A)



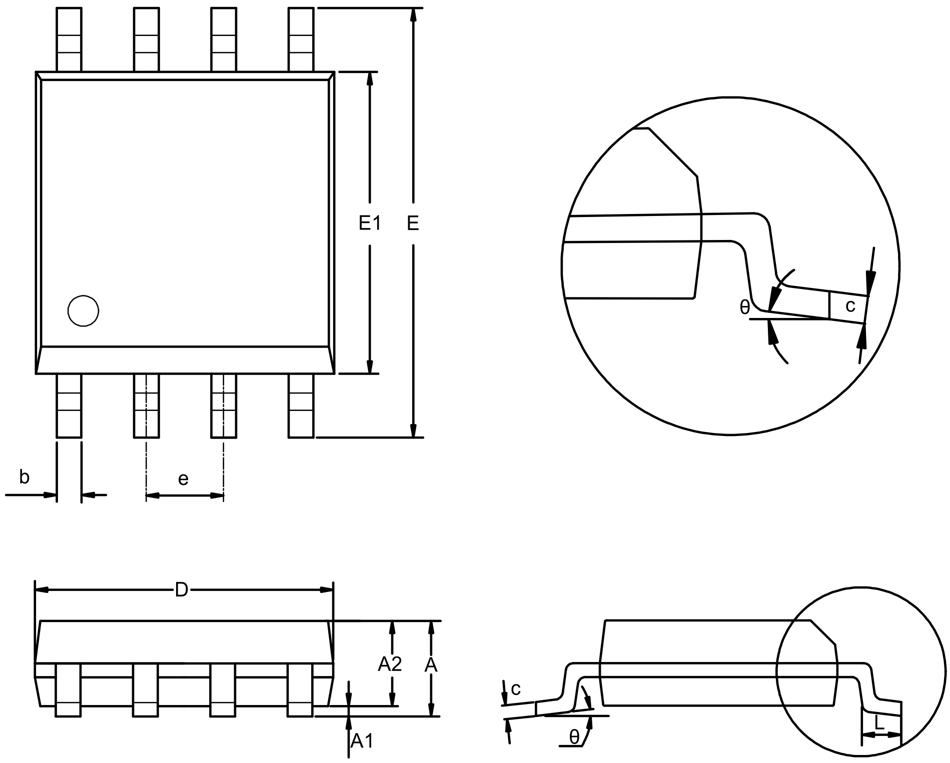
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 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.

MSOP8

Package Outline Dimensions VS1(MSOP-8-A)



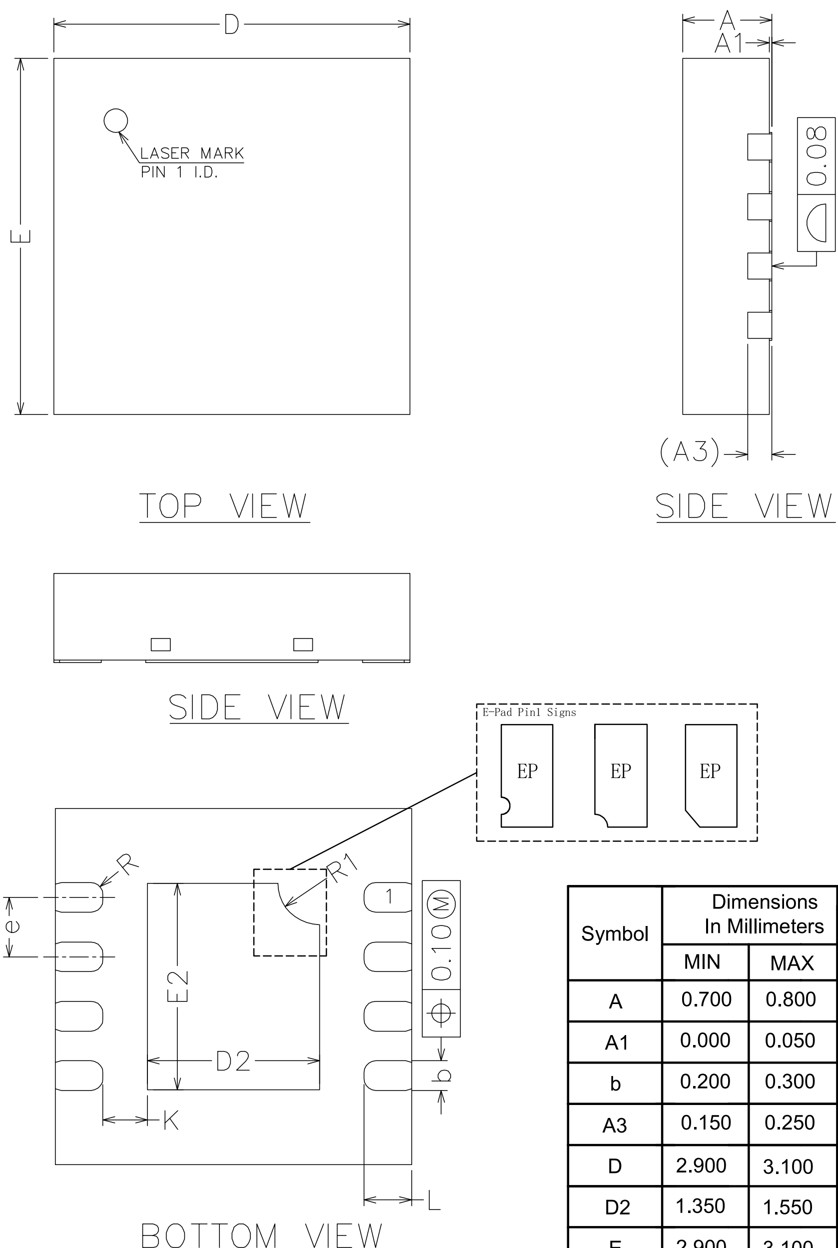
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	0	8°	0	8°

NOTES

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

DFN3X3-8

Package Outline Dimensions DF7(DFN3X3-8-D)



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
b	0.200	0.300	0.008	0.012
A3	0.150	0.250	0.006	0.010
D	2.900	3.100	0.114	0.122
D2	1.350	1.550	0.053	0.061
E	2.900	3.100	0.114	0.122
E2	1.640	1.840	0.065	0.072
e	0.500 BSC		0.020 BSC	
L	0.300	0.500	0.012	0.020

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.
3. The many types of E-pad Pin1 signs may appear in the product.

Order Information

Model Name	Order Number	Package	Transport Media, Quantity	Package Marking	Eco Plan
TPA1286	TPA1286-SO1R	8-Pin SOP8	Tape and Reel, 4,000	1286	Green
	TPA1286U-SO1R	8-Pin SOP8	Tape and Reel, 4,000	1286U	Green
	TPA1286-VS1R	8-Pin MSOP8	Tape and Reel, 3,000	1286	Green
	TPA1286U-VS1R	8-Pin MSOP8	Tape and Reel, 3,000	1286U	Green
	TPA1286U-DF7R	8-Pin DFN3X3	Tape and Reel, 4,000	286U	Green

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

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