High-Precision, High-Voltage, 2-ch Current Sense Amplifier

Features

- Voltage Offset: ±100 μV (MAX)
- Wide Common-Mode Voltage: 3 V to 76 V
- Supply Voltage: 3 V to 5.5 V
- Accuracy and Zero-Drift Performance
  - ±0.5% Gain Error (Max over temperature)
  - 0.4μV/°C Offset Drift (Max, −40°C ~125°C)
  - 10ppm/°C Gain Drift (Max)
- Three Gain Options for Voltage Output
  - TPA1285T: 20 V/V
  - TPA1285F: 50 V/V
  - TPA1285H: 100 V/V
- Rail-to-Rail Output
- Industrial –40°C to 125°C Operation Range
- ESD Rating: Robust 2.5 kV – HBM, 1.5 kV – CDM

Applications

- Current Sensing (high side)
- Battery Chargers
- Power Management
- Automotive
- Server Backplanes
- Base Stations & Telecom Equipment
- Industrial Control and Automation

Description

The TPA1285, high-precision, high common-voltage, 2-channel high-side current sense amplifier, has very high precision accuracy specifications of Vos less than 100 μV (max) and gain error less than 0.5% (max). Three fixed gains are available: 20 V/V, 50 V/V, and 100 V/V. The low offset of the zero-drift architecture enables current sensing with maximum drops across the shunt as low as 5 mV full-scale.

The TPA1285 features an input common-mode voltage ranging from 3.0 V to 76 V with 80 kHz of small-signal bandwidth, which makes it ideal for small signal conditioning interfacing with a SAR ADC.

The TPA1285 offers breakthrough performance throughout the −40°C to +125°C temperature range. It features a zero-drift core, which leads to a maxim offset drift of 0.4μV/°C throughout the operating temperature range and the common-mode voltage range. The TPA1285 is offered an 8-pin MSOP package.

Functional Block Diagram

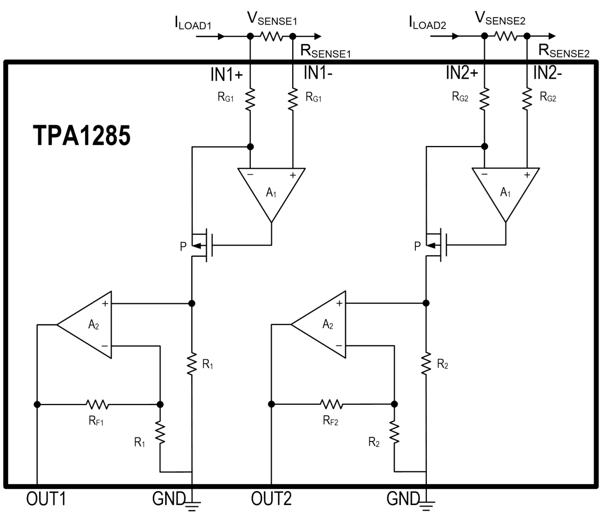


Table of Contents

Revision History

Date	Revision	Notes
2019-10-15	Rev.Pre	Initial Version.
2020-12-11	Rev.A.0	Released Version.
2021-9-22	Rev.A.1	Updated format.
2022-05-01	Rev.A.2	Updated order information and package outline dimensions.
2022-08-14	Rev.A.3	Modified absolute input common voltage and current information.
2024-12-27	Rev.A.4	The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged. • Updated to a new datasheet format. • Updated to a new format of Package Outline Dimensions. • Updated the Tape and Reel Information. • Added MSL information.

Pin Configuration and Functions

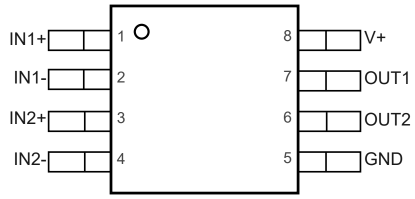


Table 1. Pin Functions

Pin		I/O	Description
No.	Name		
1	IN1+	I	Positive Input of Amplifier1
2	IN1-	I	NegativeInput of the Amplifier1.
3	IN2+	I	Positive Input of Amplifier2.
4	IN2-	I	Negative Input of the Amplifier2.
5	GND		Ground.
6	OUT2	O	Output of Amplifier2.
7	OUT1	O	Output of Amplifier1.
8	V+		Power Supply.

Specifications

Absolute Maximum Ratings (1)

Parameter		Min	Max	Unit
	Supply Voltage, ($+V_S$) − ($-V_S$)		6	V
	Input Common Voltage (Continuous)	– 0.5	80	V
	Input Common Voltage (Survival)	– 0.5	100	V
	Input Current: +IN, –IN (2)	−10	10	mA
	Current at Supply Pins	−60	+60	mA
T_J	Maximum Operating Junction Temperature		150	°C
T_A	Operating Temperature Range	−40	125	°C
T_{STG}	Storage Temperature Range	−65	150	°C
T_L	Lead Temperature (Soldering, 10 sec)		300	°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 each power supply. If the input extends more than 300 mV beyond the power supply, the input current should be limited to less than 10 mA.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 (1)	2.5	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.

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V_S	Operating Supply Voltage	3		5.5	V
V_{CM}	Common-Mode Input Voltage	3		76	V
T_A	Operating Free-Air Temperature	−40		125	°C

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
MSOP8	210	45	°C/W

Electrical Characteristics

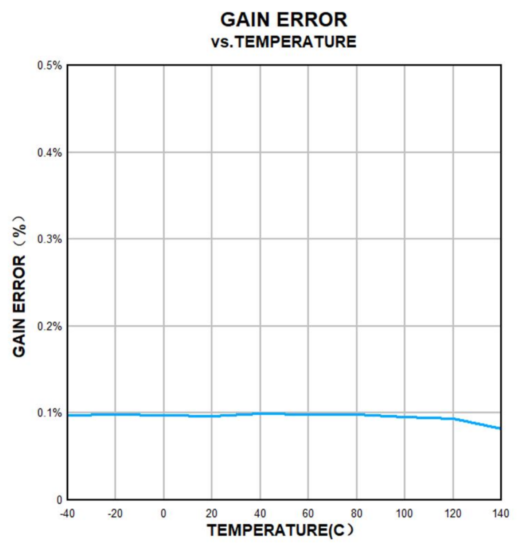
All test conditions: T_A = 25°C, $V_{SENSE} = V_{IN+} - V_{IN-}$ = 1 mV, V+ = 3.3 V, V_{IN+} = 76 V, unless otherwise noted.

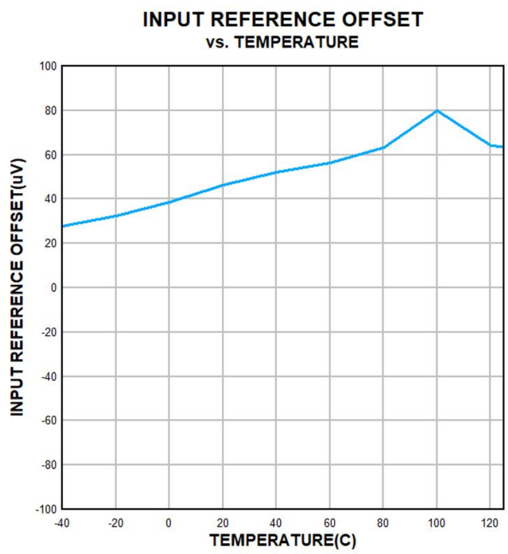
Parameter		Conditions	Min	Typ	Max	Unit
Input						
V_{OS}	Input Offset Voltage	−40°C to 125°C		±10	±100	uV
V_{OS} TC(1)	Input Offset Voltage Drift	−40°C to 125°C			0.4	μV/°C
V_{CM}	Common-mode Input Range	−40°C to 125°C	3.0		76	V
CMRR	Common Mode Rejection Ratio	−40°C to 125°C, 3.0 V < V+ < 76 V	110	125		dB
I_B	Input Bias Current	−40°C to 125°C			65	uA
I_{OS}	Input Offset Current	−40°C to 125°C			1.1	uA
PSRR	Power Supply Rejection Ratio	3.0 V < V+ < 5.5 V		100		dB
Noise RTI(2)						
e_n	Input Voltage Noise Density	f = 1kHz		40		nV/√Hz
Output						
G	Gain	TPA1285T		20		V/V
		TPA1285F		50		V/V
		TPA1285H		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	10	ppm
C_{LOAD}	Maxim capacitive load	No oscillation		1		nF
V_{OH}	Output Swing from Supply Rail	−40°C to 125°C, Source 500 uA		0.008	0.030	V
V_{OL}	Output Swing from Supply Rail	−40°C to 125°C, Sink 500 uA		0.002	0.015	V
Frequency Response						
BW	Bandwidth	All Gain Configuration		60		kHz
SR	Slew Rate			0.6		V/μs
Power Supply						
V+	Supply Voltage		3.0		5.5	V
I_Q	Quiescent Current			750	1000	μA

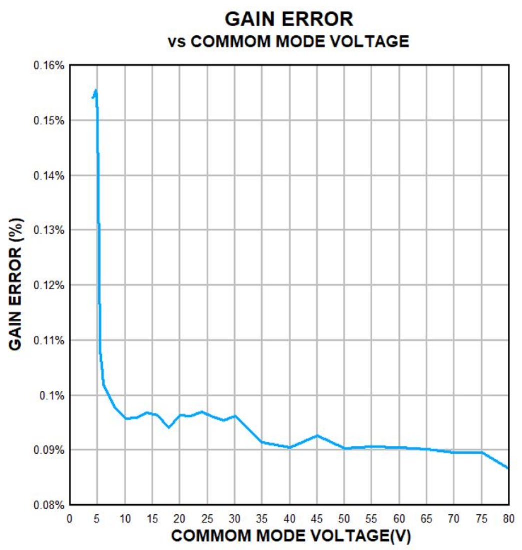
(1) Maxim specification is calculated with limited sample quantity in laboratory.
(2) RTI = referred to input.

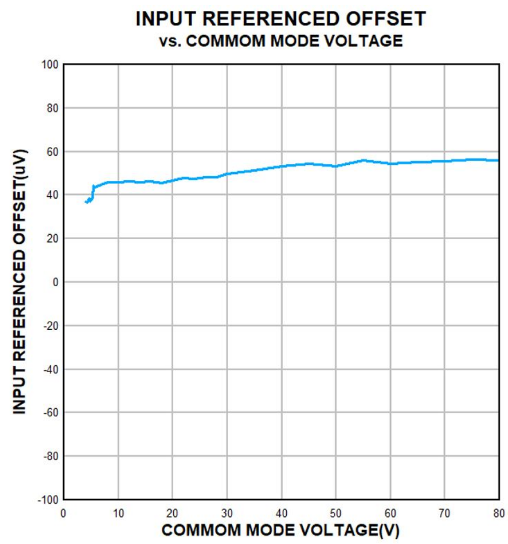
Typical Performance Characteristics

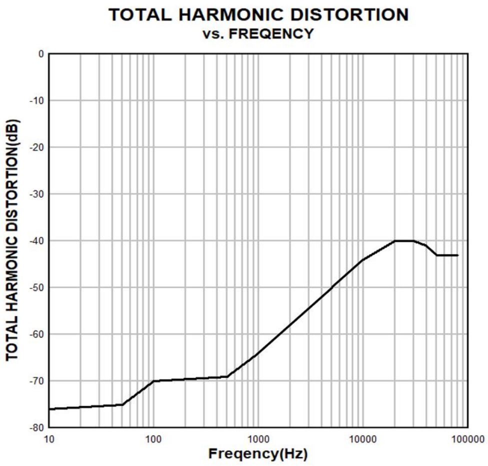
All test conditions: T_A = 25°C, V_{SENSE} = V_{IN+} – V_{IN-} = 1 mV, V+ = 3.3 V, V_{IN+} = 76 V, unless otherwise noted.

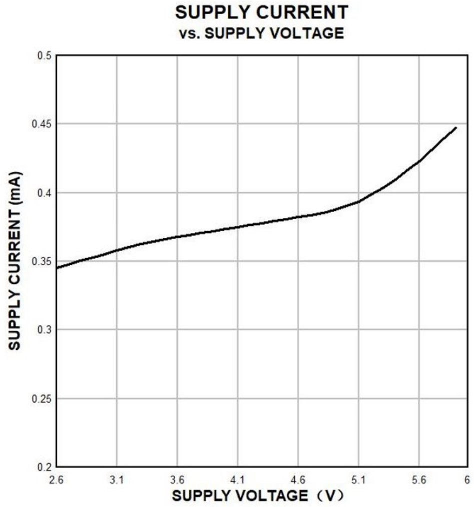


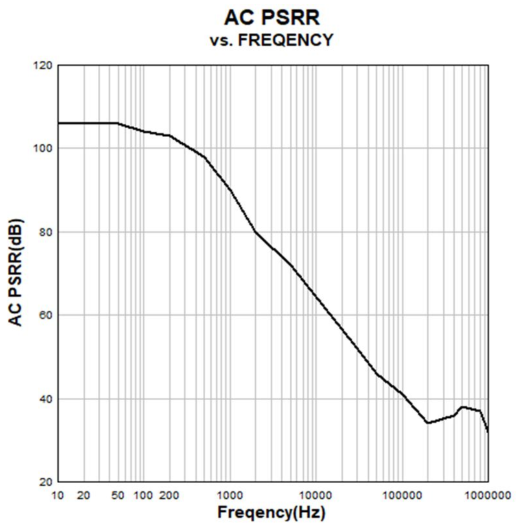


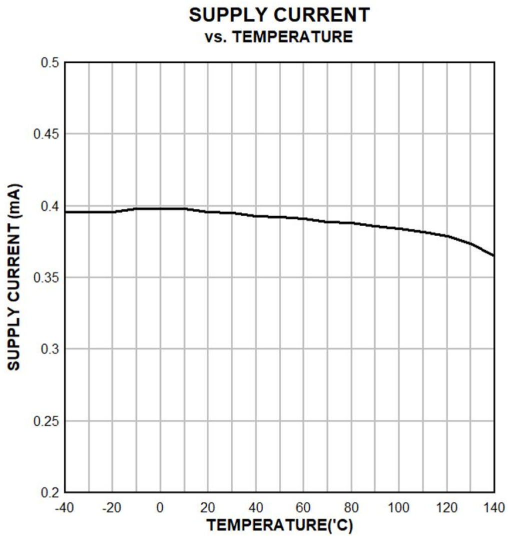


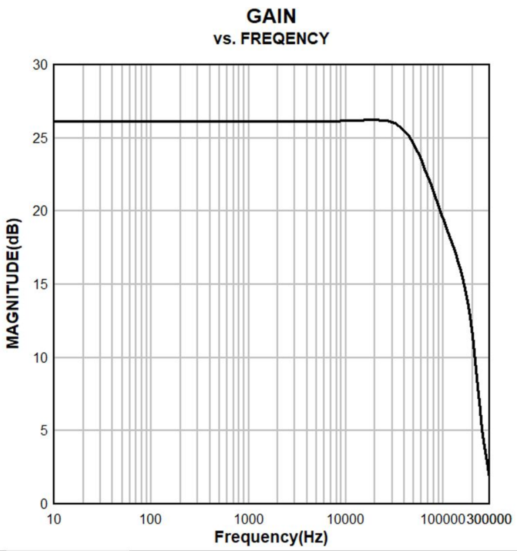


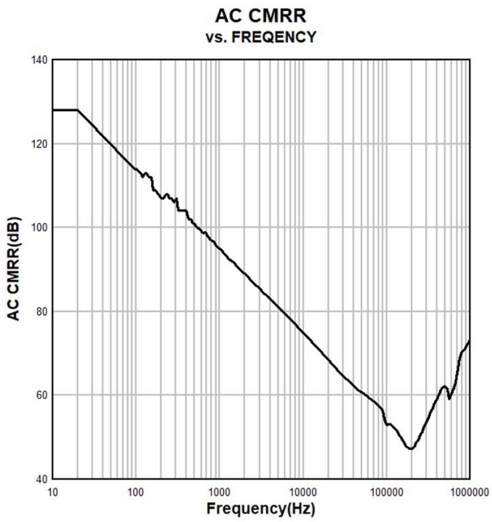

TOTAL HARMONIC DISTORTION
vs. FREQENCY
TOTAL HARMONIC DISTORTION(dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
10
100
1000
10000
100000
Freqency(Hz)

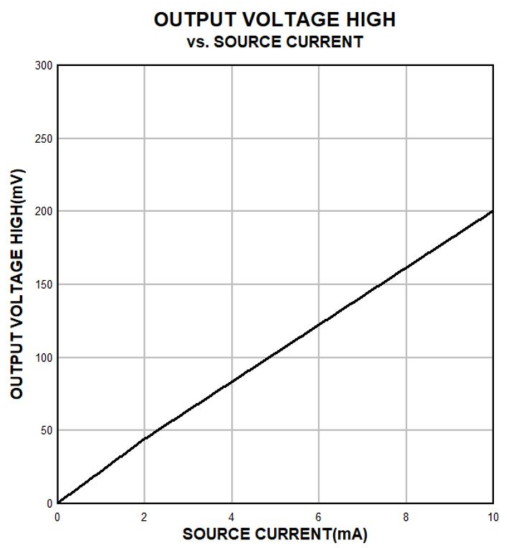

SUPPLY CURRENT
vs. SUPPLY VOLTAGE
SUPPLY CURRENT (mA)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
2.6
3.1
3.6
4.1
4.6
5.1
5.6
6
SUPPLY VOLTAGE （V）

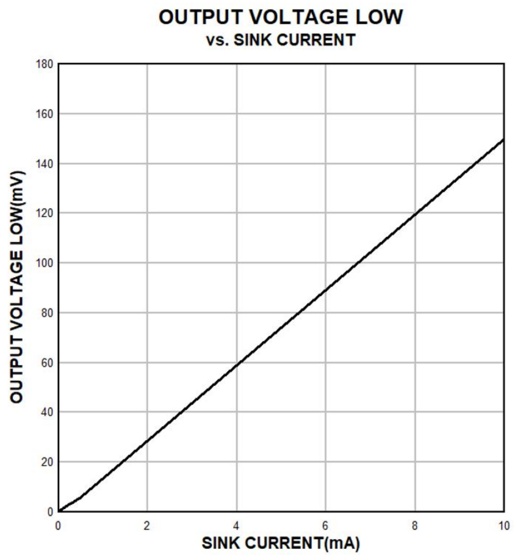

AC PSRR
vs. FREQENCY
AC PSRR(dB)
120
100
80
60
40
20
10
20
50
100
200
1000
10000
100000
1000000
Freqency(Hz)

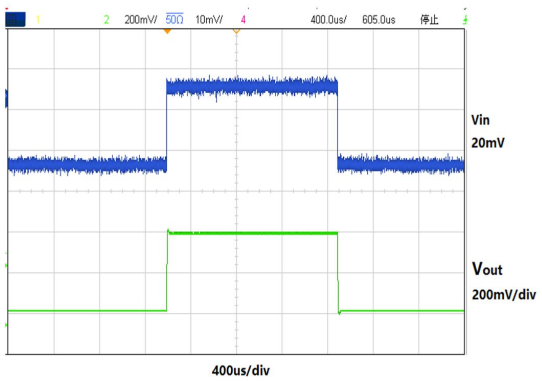

SUPPLY CURRENT
vs. TEMPERATURE
SUPPLY CURRENT (mA)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
-40
-20
0
20
40
60
80
100
120
140
TEMPERATURE('C)


GAIN
vs. FREQENCY
MAGNITUDE(dB)
30
25
20
15
10
5
0
10
100
1000
10000
100000
300000
Frequency(Hz)

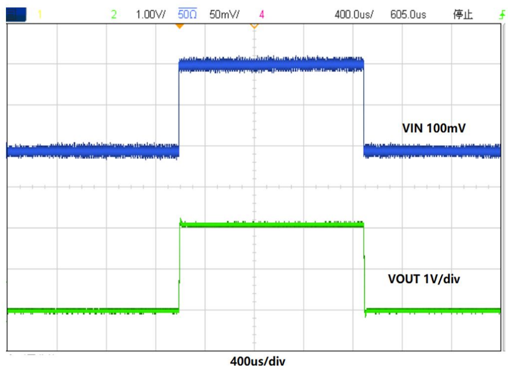

AC CMRR
vs. FREQENCY
AC CMRR(dB)
140
120
100
80
60
40
10
100
1000
10000
100000
1000000
Frequency(Hz)



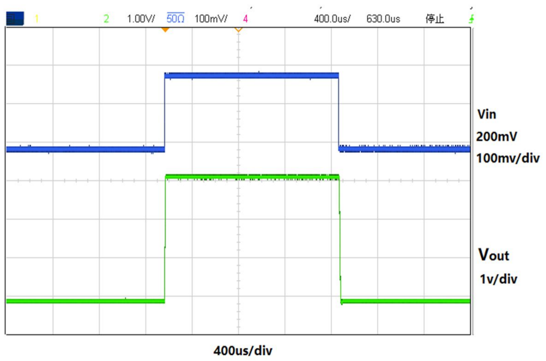




Small-Signal Response



Large-Signal Response



Saturation Recovery Response

Detailed Description

Overview

The TPA1285 family is a high-voltage power supply, zero-drift, 2-channel difference amplifier that uses unique architecture to accurately amplify small differential current shunt voltages, especially for fast changing common-mode voltages. In typical applications, the TPA1285 family 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.

Functional Block Diagram

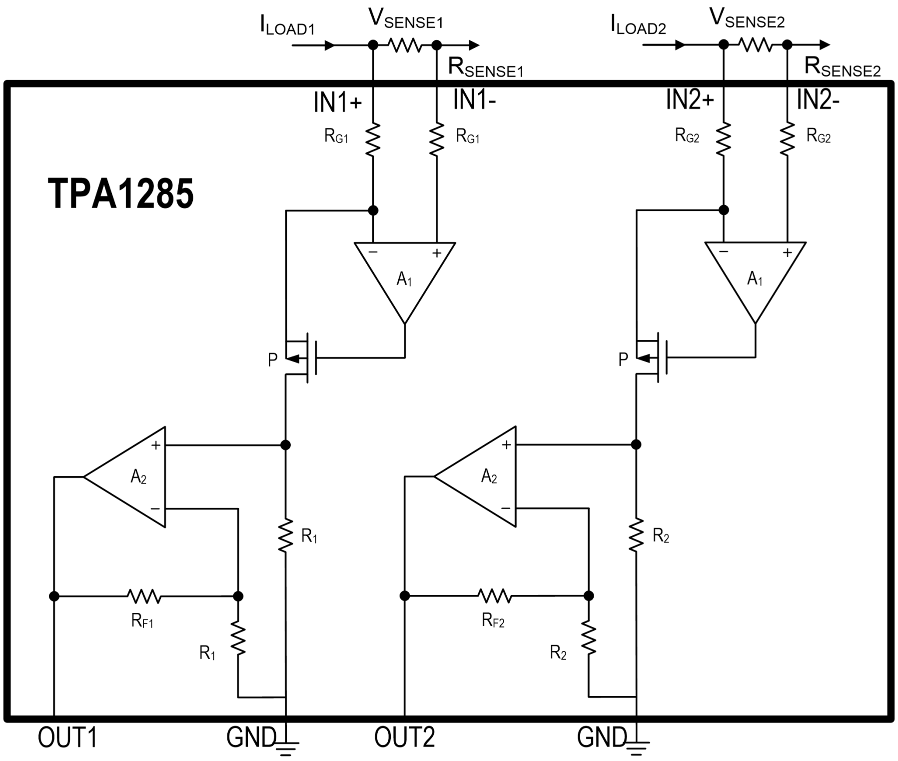


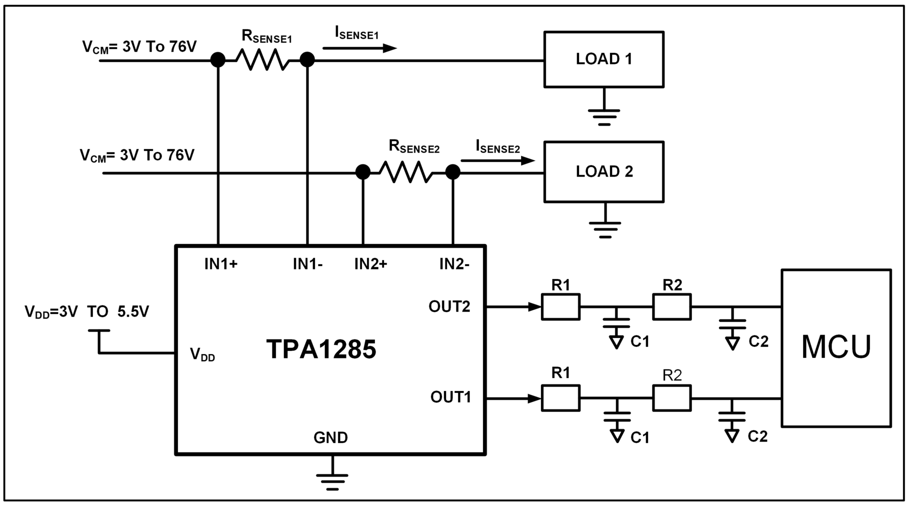
Figure 1. Functional Block Diagram

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.

Typical Application



Selecting Rsense

The zero-drift offset performance of the TPA1285 offers several benefits. Most often, the primary advantage of the low-offset characteristic enables lower full-scale drops across the Rsense. For example, non-zero-drift current sense monitors typically require a full-scale range of 100 mV. The TPA1285 family gives equivalent accuracy at a full-scale range on the order of 5~10 mV. This accuracy reduces Rsense 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 on the low end of the measurement. Most often, these applications can use the lower gains of the TPA1285 to accommodate larger Rsense drops on 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:

$$V_{OUT} = V_{sense} \times A_V \quad (1)$$

Where Vsense is the full-scale sense voltage, and Av is the gain of the TPA1285.

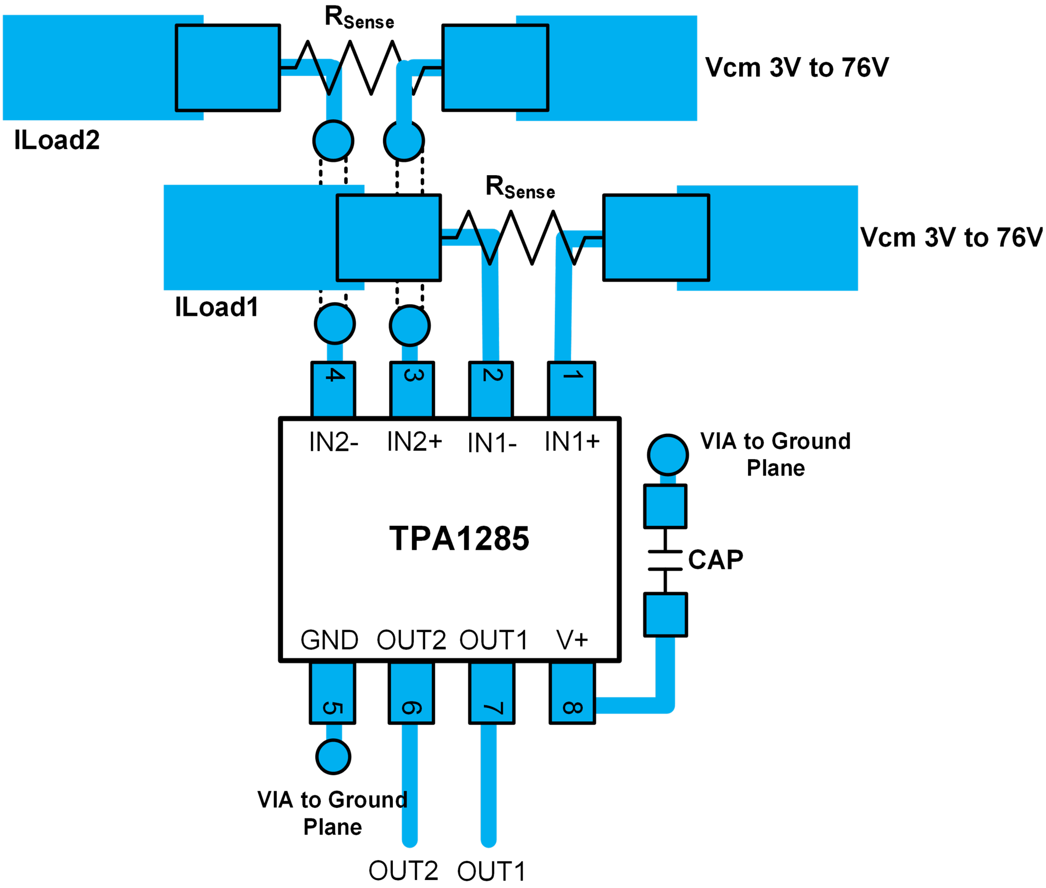
In applications of monitoring a high current, ensure that Rsense is able to dissipate its own I^2R power loss. If the resistor's power dissipation exceeds the nominal value, its value may drift, or it may fail altogether. The TPA1285 senses a wide variety of currents with different sense-resistor values.

Power Supply Recommendation

The input circuitry of the TPA1285 can accurately measure beyond its power-supply voltage, V+. For example, the V+ power supply can be 5 V, whereas the load power-supply voltage can be as high as 76 V. However, the output voltage range of the OUT pin is limited by the voltages on the power-supply pin.

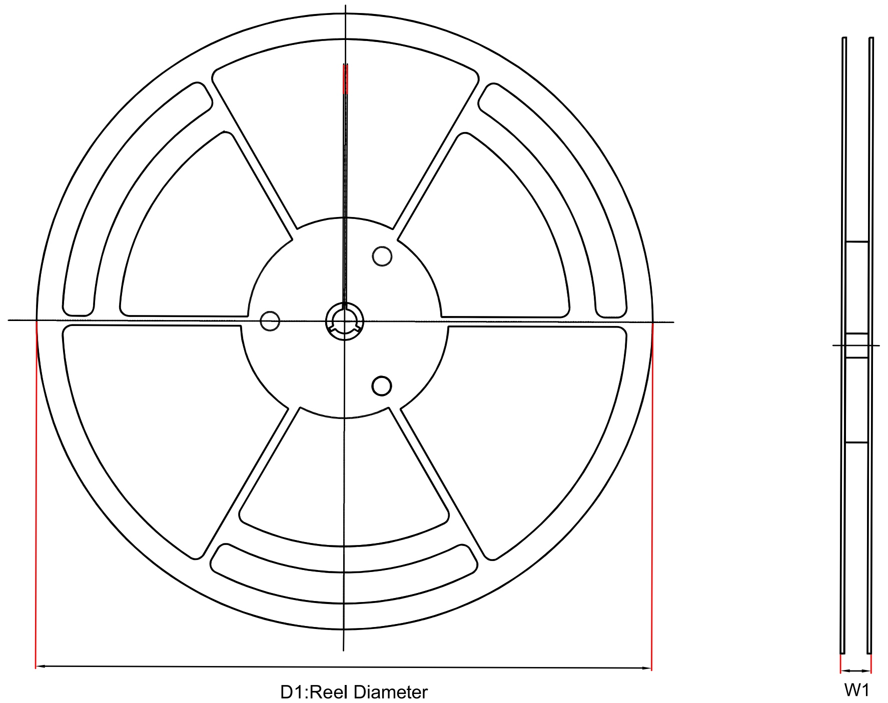
Proper Board Layout

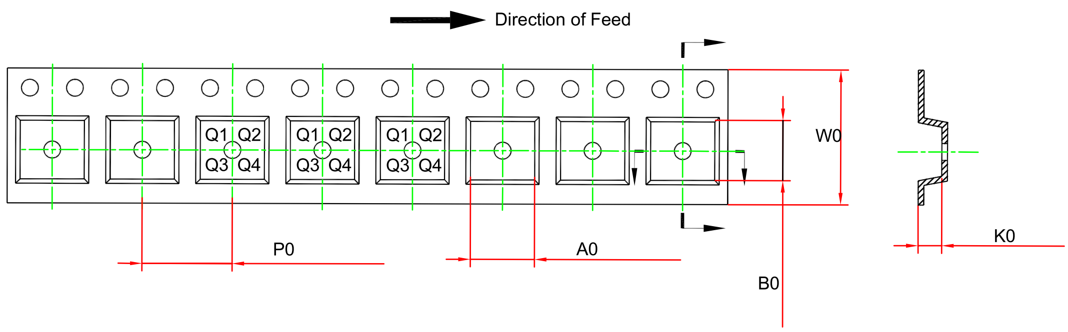
To ensure optimum performance at the PCB level, care must be taken in the design of the board layout. Poor routing of the current sensing resistor can result in additional resistance between the input pins of the amplifier. Any additional high-current carrying impedance can cause significant measurement errors because the current resistor has a very low value. Below is recommended connection to connect to the device input pins. This connection ensures that only the current-sensing resistor impedance is detected between the input pins.



The use of a ground plane is highly recommended. A ground plane reduces EMI noise and helps to maintain a constant temperature across the circuit board.

Tape and Reel Information





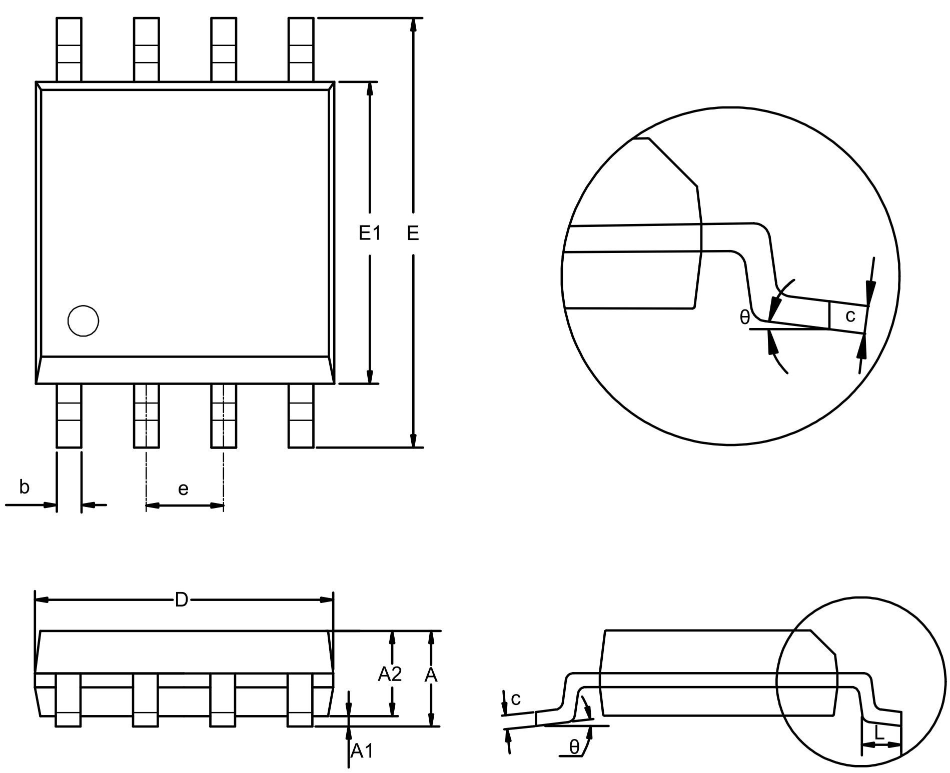
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) (1)	B0 (mm) (1)	K0 (mm) (1)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA1285T-VR-S	MSOP8	330	17.6	5.3	3.4	1.3	8	12	Q1
TPA1285F-VR-S	MSOP8	330	17.6	5.3	3.4	1.3	8	12	Q1
TPA1285H-VR-S	MSOP8	330	17.6	5.3	3.4	1.3	8	12	Q1

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

Package Outline Dimensions

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.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPA1285T-VR-S	−40 to 125°C	MSOP8	1285T	MSL3	Tape and Reel, 3,000	Green
TPA1285F-VR-S (1)	−40 to 125°C	MSOP8	1285F	MSL3	Tape and Reel, 3,000	Green
TPA1285H-VR-S (1)	−40 to 125°C	MSOP8	1285H	MSL3	Tape and Reel, 3,000	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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