36-V Dual Operational Amplifiers with Internal 2.5-V Reference

Features

- Operational Amplifier
  - Supply Voltage: 3 V to 36 V
  - Low Supply Current: 220 µA (Max)
  - Input Rail to $-V_S$, Rail-to-Rail Output
  - Excellent High-Frequency PSRR+: 65 dB at 100 kHz
  - Offset Voltage of TPA7252/7252A: ±4 mV at 25°C (Max)
  - Offset Voltage of TPA7253/7253A: ±2 mV at 25°C (Max)
- Voltage Reference
  - 2.5-V Output, Stable with No Load to 1-µF Load
  - TPA7252/7253: 1% Initial Accuracy
  - TPA7252A/7253A: 0.4% Initial Accuracy
- Operating Temperature Range: −40°C to 125°C

Applications

- Power Module
- Adapter
- Led Lighting

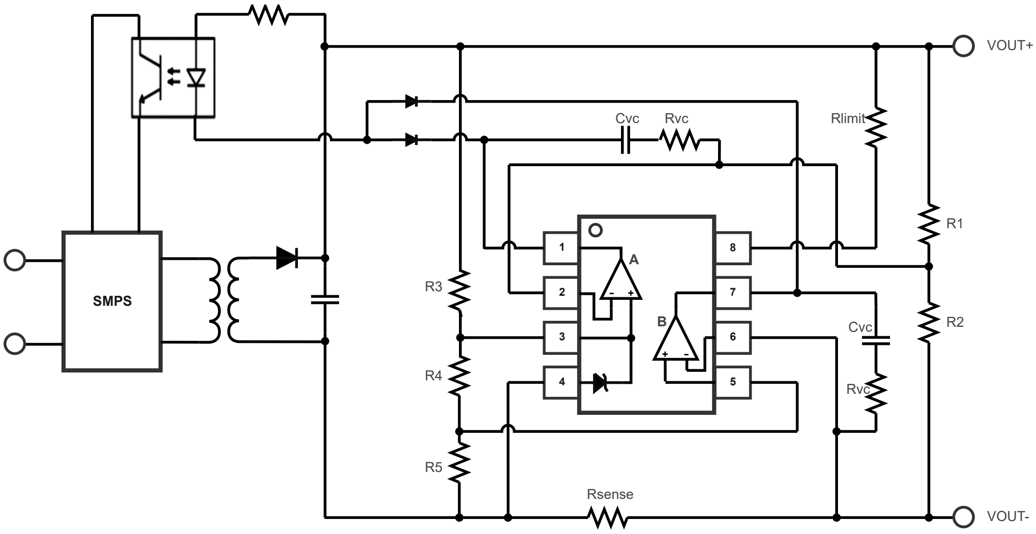
Description

The device combines a dual operational amplifier and a fixed 2.5-V shunt voltage reference, which are often used in the control circuitry of power supplies.

The operational amplifier A has the non-inverting input internally tied to the shunt reference which is used for the voltage control loop. The operational amplifier B is independent of the current control loop.

The device has a 220-µA power supply excluding the current in the reference, and the minimum working current for the reference is 50 µA, which can be used in low-power applications.

Typical Application Circuit



TPA7252 in a Constant-Current and Constant-Voltage Battery Charger

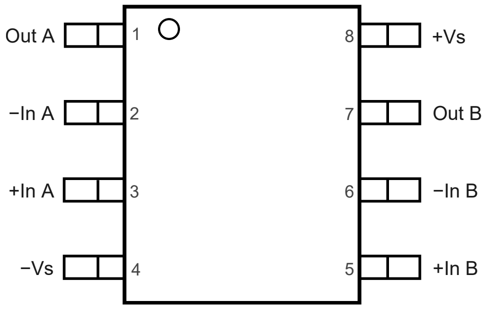
Table of Contents

Revision History

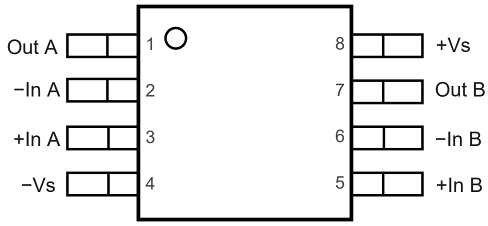
Date	Revision	Notes
2021-12-20	Rev.A.0	Initial version.
2022-03-28	Rev.A.1	Corrected typo on page 7: from "Reference Voltage, TPA7252, 0.4%" to "Reference Voltage, TPA7252A, 0.4%".
2023-05-10	Rev.A.2	Updated the document format.
2023-08-17	Rev.A.3	Added Input Voltage Noise Density in Electrical Characteristics. Updated Figure 2.
2023-11-08	Rev.A.4	Added products: TPA7253 and TPA7253A.
2024-01-25	Rev.A.5	Added typical value of V_{OS} in Electrical Characteristics.
2024-03-18	Rev.A.6	The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged. Updated the pin configuration of the SOP8 package.
2024-12-18	Rev.A.7	The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged. Updated the Tape and Reel Information.
2025-09-17	Rev.A.8	The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged. Corrected the Marking Information of the TPA7253 from A7252 to A7253.

Pin Configuration and Functions

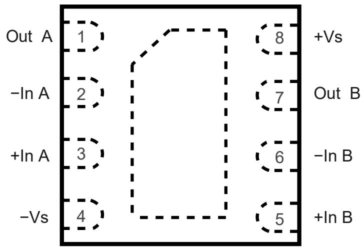
TPA725x
SOP8
Top View



TPA725x
MSOP8
Top View



TPA725x
DFN2X2-8
Top View



The thermal pad of DFN2X2-8 is recommended to be left or connected to $-V_S$.

Table 1. Pin Functions: TPA725x

Pin No.	Name	I/O	Description
1	Out A	O	Output of the channel A.
2	−In A	I	Inverting input of the channel A.
3	+In A	I	Non-inverting input of the channel A.
4	$-V_S$	I	Negative power supply.
5	+In B	I	Non-inverting input of the channel B.
6	−In B	I	Inverting input of the channel B.
7	Out B	O	Output of the channel B.
8	$+V_S$	I	Positive power supply.

Specifications

Absolute Maximum Ratings (1)

Parameter		Min	Max	Unit
	Supply Voltage, $(+V_S) - (-V_S)$		40	V
	Input Voltage	$(-V_S) - 0.3$	$(+V_S) + 0.3$	V
	Differential Input Voltage	$(-V_S) - (+V_S)$	$(+V_S) - (-V_S)$	V
	Input Current: +IN, –IN (2)	−10	10	mA
	Output Voltage	$(-V_S) - 0.3$	$(+V_S) + 0.3$	V
	Output Short-Circuit Duration (3)		Infinite	
T_J	Maximum 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)		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) 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.
(3) A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

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	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	Supply Voltage, $(+V_S) - (-V_S)$	3		36	V
	Cathode Current of Reference	0.08		100	mA
T_A	Operating Temperature Range	−40		125	°C

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOP8	158	43	°C/W
MSOP8	210	45	°C/W
DFN2X2-8	100	60	°C/W

Electrical Characteristics

All test conditions: T_A = 25°C, V_S = 5 V, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Power Supply						
V_S	Supply Voltage Range		3		36	V
I_Q	Quiescent Current excluding Current in Voltage Reference, No Load	V_S = 30 V		110	220	μA
		V_S = 30 V, T_A = −40°C to 125°C			300	μA
		V_S = 5 V		100	200	μA
		V_S = 5 V, T_A = −40°C to 125°C			270	μA
Voltage Reference						
	Reference Voltage, TPA7252, TPA7253, 1%	I_K = 10 mA,	2.475	2.50	2.525	V
		I_K = 10 mA, T_A = −40°C to 125°C	2.45		2.55	V
	Reference Voltage, TPA7252A, TPA7253A, 0.4%	I_K = 10 mA,	2.49	2.50	2.51	V
		I_K = 10 mA, T_A = −40°C to 125°C	2.48		2.52	V
	Reference Voltage Deviation	I_K = 10 mA, T_A = −40°C to 105°C		1	15	mV
	Minimum Cathode Current for Regulation			0.01	0.05	mA
		T_A = −40°C to 125°C			0.08	mA
	Dynamic Impedance	I_K = 1 mA to 100 mA, f < 1 kHz		0.2		Ω
	Capacitive Load	T_A = −40 to 125°C			1	μF
OPA - Input Characteristics						
V_{OS}	Input Offset Voltage, TPA7252, TPA7252A	V_S = 36 V, V_{CM} = 0 V to 34.5 V	−4	±1	4	mV
		V_S = 36 V, V_{CM} = 0 V to 34.5 V, T_A = −40°C to 125°C	−5		5	mV
		V_S = 5 V, V_{CM} = 0 V to 3.5 V	−4	±1	4	mV
		V_S = 5 V, V_{CM} = 0 V to 3.5 V, T_A = −40°C to 125°C	−5		5	mV
V_{OS}	Input Offset Voltage, TPA7253, TPA7253A	V_S = 36 V, V_{CM} = 0 V to 34.5 V	−2	±1	2	mV
		V_S = 36 V, V_{CM} = 0 V to 34.5 V, T_A = −40°C to 125°C	−3		3	mV
		V_S = 5 V, V_{CM} = 0 V to 3.5 V	−2	±1	2	mV
		V_S = 5 V, V_{CM} = 0 V to 3.5 V, T_A = −40°C to 125°C	−3		3	mV
V_{OS} TC	Input Offset Voltage Drift	V_{CM} = 0 V to 2.5 V, T_A = −40°C to 125°C		3		μV/°C
I_B	Input Bias Current	V_{CM} = 0 V		10		pA
		V_{CM} = 0 V, T_A = −40°C to 125°C		1		nA
I_{OS}	Input Offset Current	V_{CM} = 0 V		10		pA
		V_{CM} = 0 V, T_A = −40°C to 125°C		1		nA

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
A_V	Open−Loop Voltage Gain	V_S = 30 V, V_O = 2 V to 26 V	95	110		dB
		V_S = 30 V, V_O = 2 V to 26 V, T_A = −40°C to 125°C	90			dB
V_{CMR}	Common-Mode Input Voltage Range	T_A = −40°C to 125°C	(−V_S)		(+V_S) – 1.5	V
OPA - Input Characteristics						
CMRR	Common-Mode Rejection Ratio, Channel B only	V_S = 36 V, V_{CM} = 0 V to 34.5 V	80	100		dB
		V_S = 36 V, V_{CM} = 0 V to 34.5 V, T_A = −40°C to 125°C	70			dB
PSRR	Power Supply Rejection Ratio	V_S = 5 V to 36 V	85	120		dB
		V_S = 5 to 36 V, T_A = −40°C to 125°C	80			dB
OPA - Output Characteristics						
V_{OH}	Output Voltage High	V_S = 30 V, R_L = 2 kΩ to (−V_S)	26	27		V
		V_S = 30 V, R_L = 2 kΩ to (−V_S), T_A = −40°C to 125°C	26			V
		V_S = 30 V, R_L = 10 kΩ to (−V_S)	27	28		V
		V_S = 30 V, R_L = 10 kΩ to (−V_S), T_A = −40°C to 125°C	27			V
V_{OL}	Output Voltage Low	V_S = 30 V, R_L = 10 kΩ to (−V_S)		1	15	mV
		V_S = 30 V, R_L = 10 kΩ to (−V_S), T_A = −40°C to 125°C			20	mV
I_{OUT}	Output Current, Source	V_S = 15 V, V_{ID} = 1 V, V_O = 2 V	20	40		mA
		V_S = 15 V, V_{ID} = 1 V, V_O = 2 V, T_A = −40°C to 125°C	10			mA
	Output Current, Sink	V_S = 15 V, V_{ID} = −1 V, V_O = 2 V	10	20		mA
		V_S = 15 V, V_{ID} = −1 V, V_O = 2 V, T_A = −40°C to 125°C	5			mA
		V_S = 15 V, V_{ID} = −1 V, V_O = 0.2 V	12	50		μA
		V_S = 15 V, V_{ID} = −1 V, V_O = 0.2 V, T_A = −40°C to 125°C	5			μA
I_{SC}	Output Short-Circuit Current	V_S = 15 V		50		mA
OPA - AC Characteristics						
GBW	Gain-Bandwidth Product			1		MHz
SR	Slew Rate	G = 1, 2-V step		0.9		V/μs
PM	Phase Margin	R_L = 10 kΩ, C_L = 100 pF		50		°
GM	Gain Margin	R_L = 10 kΩ, C_L = 100 pF		6		dB
OPA - Noise Performance						
E_N	Input Voltage Noise	f = 0.1 Hz to 10 Hz		1		μV_{RMS}
e_N	Input Voltage Noise Density	f = 1 kHz		65		nV/√Hz

Typical Performance Characteristics

All test conditions: V_{IN} = 5 V, T_A = 25°C, unless otherwise noted.

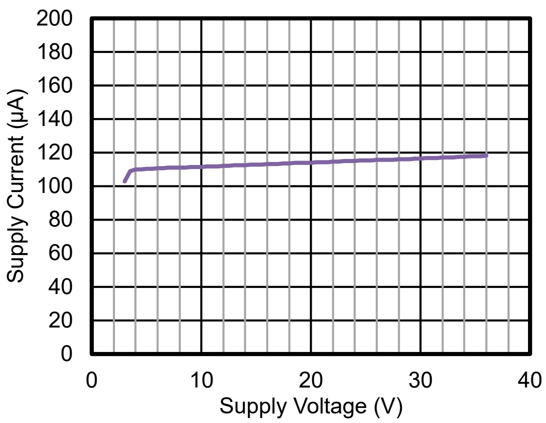


Figure 1. Supply Current vs. Supply Voltage

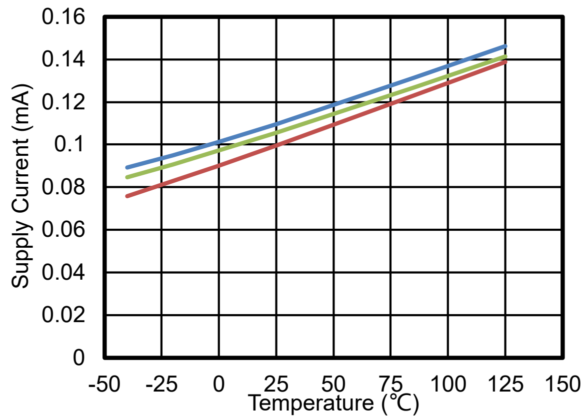


Figure 2. Supply Current vs. Temperature, V_S = 15 V

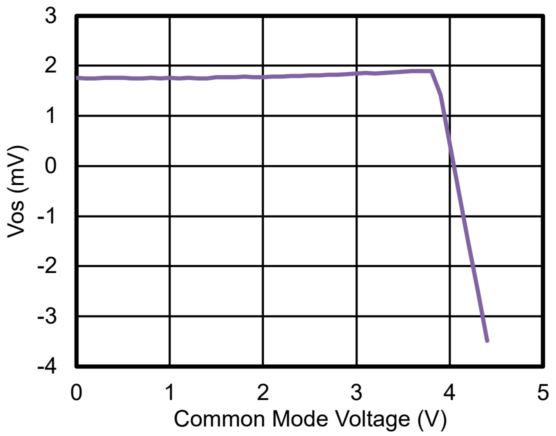


Figure 3. V_{OS} vs. V_{CM}, V_S = 5 V

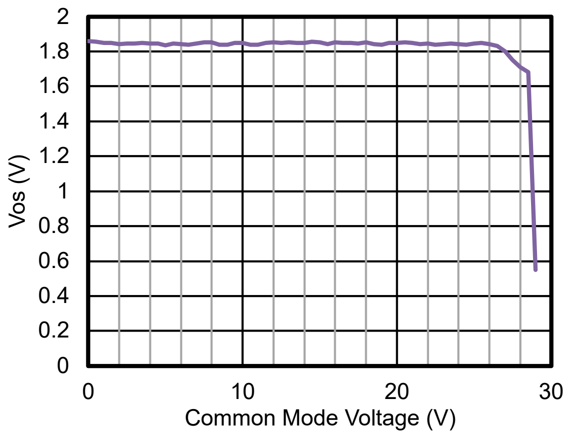


Figure 4. V_{OS} vs. V_{CM}, V_S = 30 V

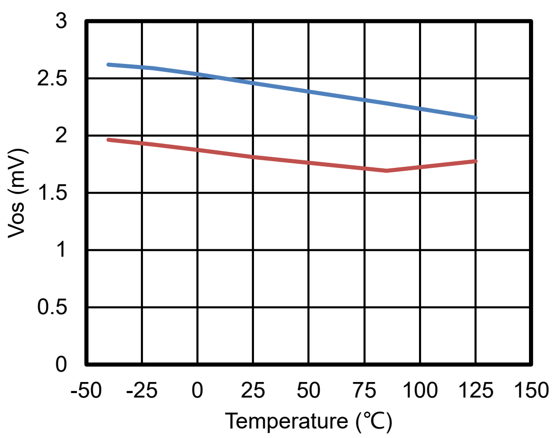


Figure 5. V_{OS} vs. Temperature, V_S = 5 V, V_{CM} = 2.5 V

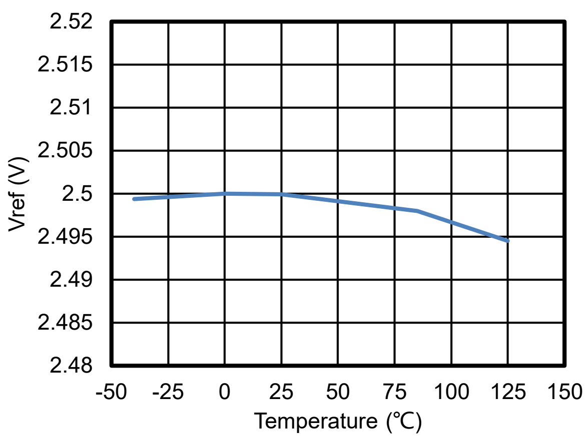


Figure 6. Reference Output vs. Temperature

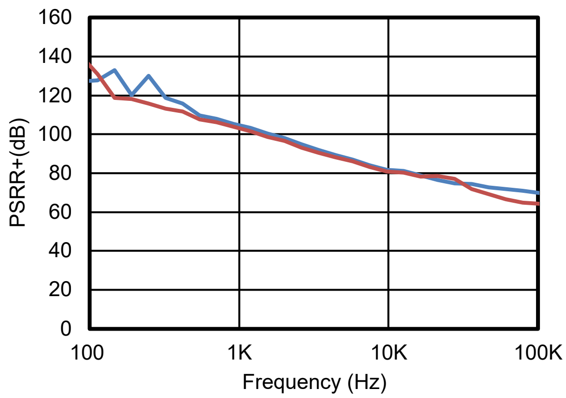


Figure 7. PSRR+ vs. Frequency

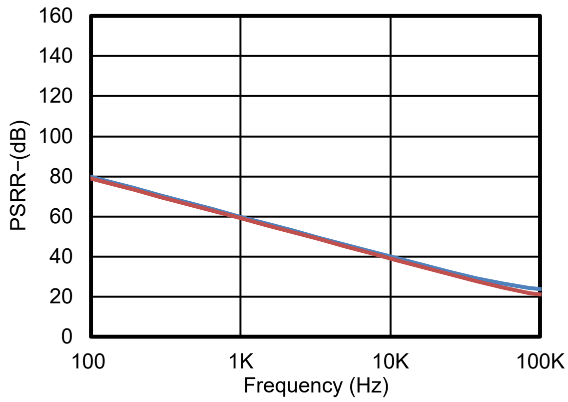


Figure 8. PSRR− vs. Frequency

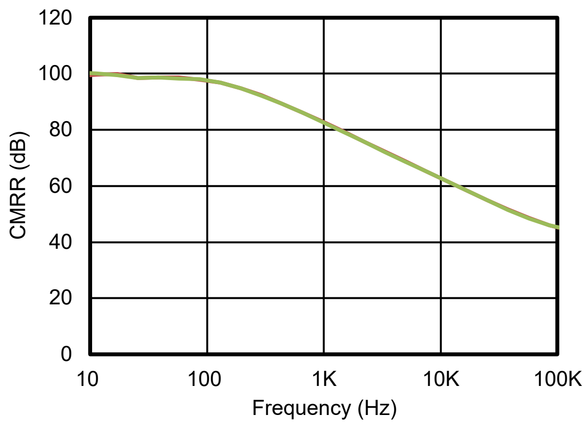
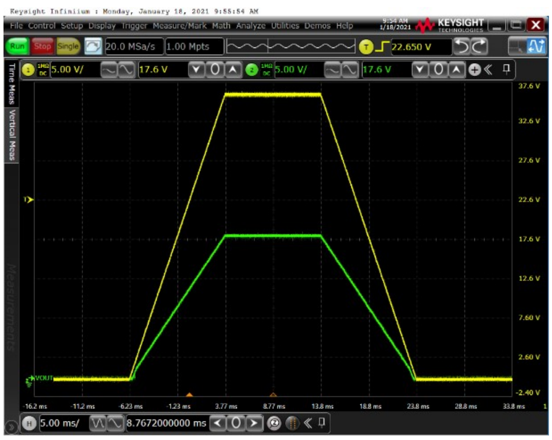


Figure 9. CMRR vs. Frequency

G = 1, V_{IN} = 1/2 V_S during Power-on and Power-off,

Yellow: +V_S; Green: Output

Figure 10. Power-on and Power-off Behavior, 2 ms



G = 1, V_{IN} = 4 V during Power-on and Power-off,

Yellow: +V_S; Green: Output

Figure 11. Power-on and Power-off Behavior, 10 ms

G = 1, V_{IN} = 4 V during Power-on and Power-off,

Yellow: +V_S; Green: Output

Figure 12. Power-on and Power-off Behavior, 100 ms

Detailed Description

Overview

The device combines a dual operational amplifier and a fixed 2.5-V shunt voltage reference. The operational amplifier A has the non-inverting input internally tied to the shunt reference which is used for the voltage control loop. The operational amplifier B is independent of the current control loop.

Functional Block Diagram

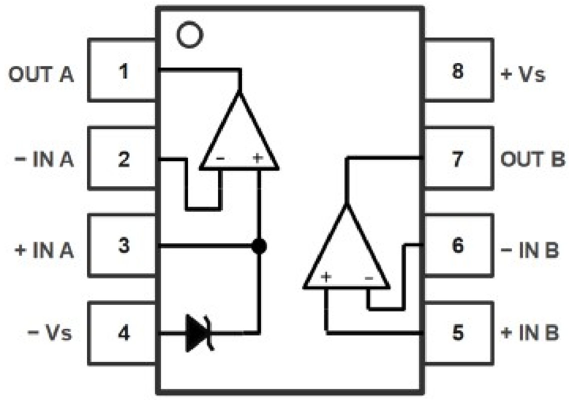


Figure 13. Functional Block Diagram

Feature Description

Operating Voltage

The device is designed for single-supply operation from 3 V to 36 V, or dual-supply operation from ±1.5 V to ±18 V. The high-power supply voltage helps the device survive on the noisy power supply.

Low Power Operation

The device has a 220-μA power supply excluding the current in the reference, and the minimum working current for the reference is 50 μA, which is very useful in low-power applications.

PSRR+ of the Operational Amplifier

The operation amplifier in the device has 65-dB PSRR+ at 100-kHz frequency. This feature reduces the output noise of the operational amplifier produced by the noisy power supply.

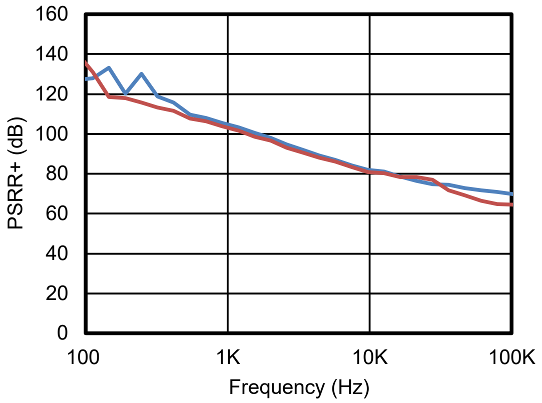


Figure 14. PSRR+ vs. Frequency

Region of Reference Stability

The reference of the device can work stably with a large range of capacitive loads. Figure 15 shows the stability of reference output with 10-ms power-on time:

- "s" means the output is stable.
- "R1" means the output has a ring (< 100 mV) in the power-on time and is stable when the output reaches the final value.
- "R2" means the output has a ring (< 100 mV) and is stable in 1 ms.

Ik (mA) \ Capacitor (nF) on Vref	0	0.1	0.47	1	4.7	47	100	200	300	1000
100	s	s	s	s	s	s	R2	R2	R2	R2
50	s	s	s	s	s	s	R2	R2	R2	R2
40	s	s	s	s	s	s	R2	R2	R2	R2
30	s	s	s	s	s	s	R2	R2	R2	R2
25	s	s	s	s	s	s	R2	R2	R2	R2
20	s	s	s	s	s	s	R2	R2	R2	R2
15	s	s	s	s	s	s	R2	R2	R2	R2
10	s	s	s	s	s	s	R2	R2	R2	R2
7.5	s	s	s	s	s	s	R2	R2	R2	R2
5	s	s	s	s	s	s	s	s	s	s
2.5	s	s	s	s	s	s	s	s	s	s
1	R1	R1	s	s	s	s	s	s	s	s
0.5	R1	R1	s	s	s	s	s	s	s	s
0.25	R1	R1	s	s	s	s	s	s	s	s
0.1	R1	R1	R1	s	s	s	s	s	s	s
0.05	R1	R1	R1	R1	s	s	s	s	s	s

Figure 15. Region of Reference Stability vs. Capacitive Load

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

Power Supply Recommendations

Place 0.1-μF bypass capacitors close to the power-supply pins to reduce coupling errors from the noise or high-impedance power supplies.

Typical Application

Figure 16 shows the typical application schematic.

Constant-Current and Constant-Voltage Battery Charger

Figure 16 shows the device configured in a constant-current and constant-voltage battery charger.

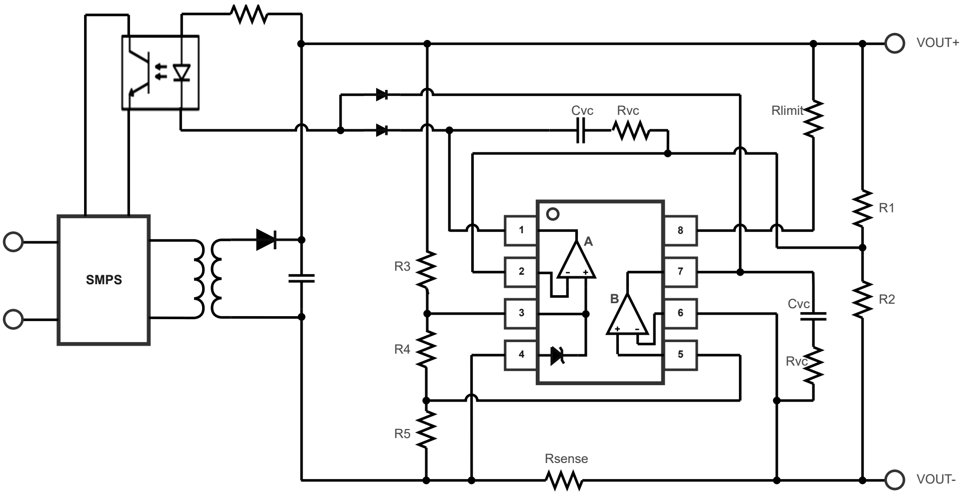


Figure 16. TPA725x in a Constant-Current and Constant-Voltage Battery Charger

The voltage control loop is controlled by the operational amplifier A and the resistor divider (R1, R2), and the output voltage is given in Equation 1.

$$V_{OUT} = V_{REF}\frac{R1 + R2}{R2} \quad (1)$$

Where V_{OUT} is the desired maximum output voltage, and V_{REF} is the output voltage of internal reference.

The current control loop is controlled by the operational amplifier B and the resistor divider (R4, R5) tied to the voltage reference. The voltage on R_{SENSE} is given in Equation 2.

$$V_{SENSE} = V_{REF}\frac{R5}{R4 + R5} \quad (2)$$

Where V_{SENSE} is the voltage on R_{SENSE}.

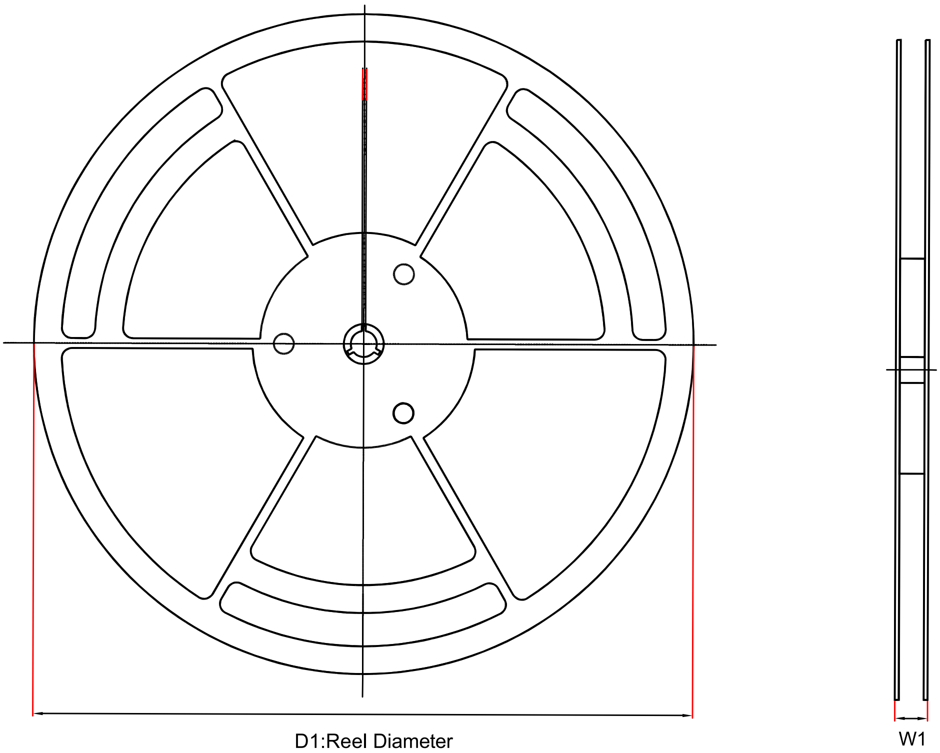
Then the maximum output current is given in Equation 3.

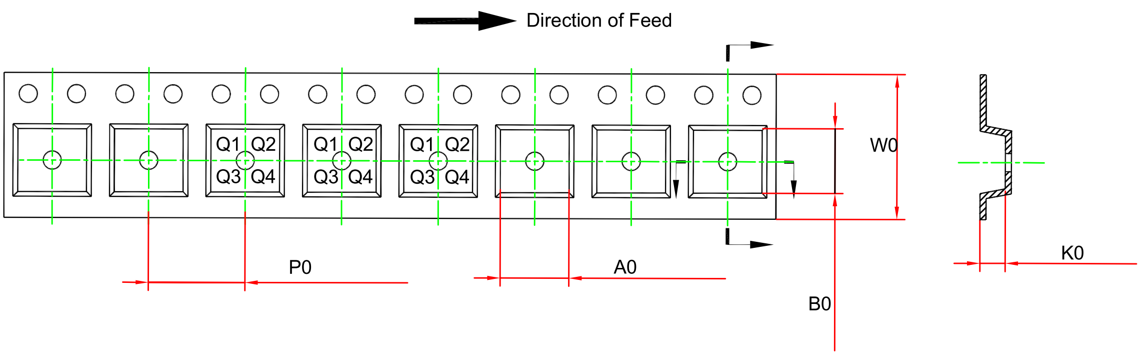
$$I_{OUT} = \frac{V_{SENSE}}{R_{SENSE}} \tag{3}$$

Where I_{OUT} is the desired maximum output current.

The outputs of the two operational amplifiers are connected to the opto-coupler through the diode, which makes an ORing function that ensures whenever the values of the current or the voltage reach too high, the opto-coupler is activated.

Tape and Reel Information





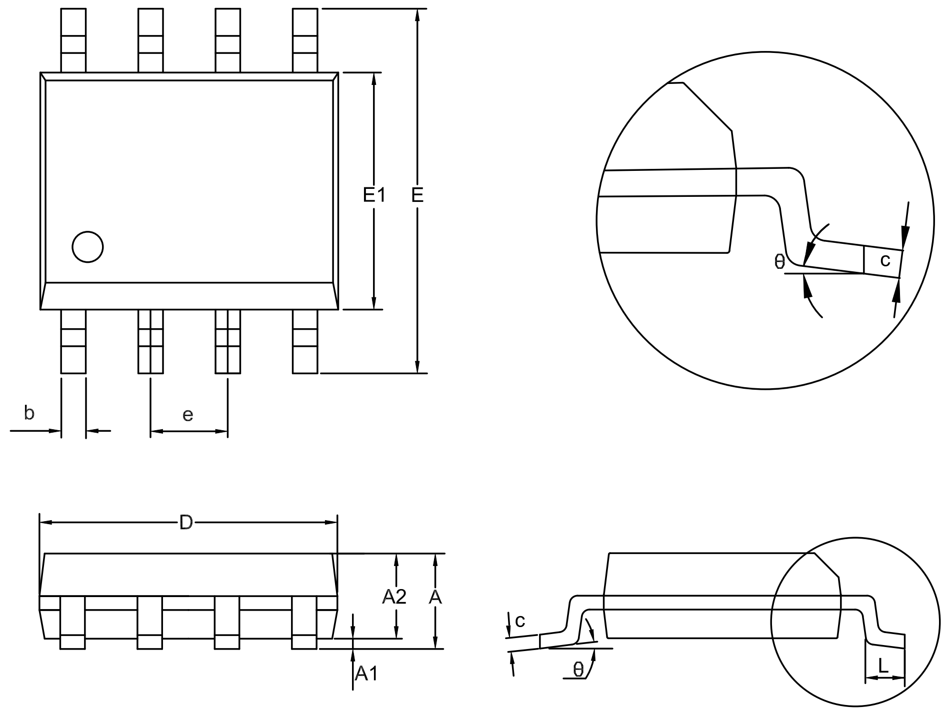
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) (1)	B0 (mm) (1)	K0 (mm) (1)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA725x-SO1R	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA725xA-SO1R	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA725x-DF4R	DFN2X2-8	180.0	13.1	2.3	2.3	1.1	4.0	8.0	Pending
TPA725x-VS1R	MSOP8	330.0	17.6	5.2	3.3	1.5	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-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.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPA7252-SO1R	−40 to 125°C	SOP8	A7252	3	Tape and Reel, 4000	Green
TPA7252A-SO1R	−40 to 125°C	SOP8	A7252	3	Tape and Reel, 4000	Green
TPA7253-SO1R	−40 to 125°C	SOP8	A7253	3	Tape and Reel, 4000	Green
TPA7253A-SO1R	−40 to 125°C	SOP8	A7253	3	Tape and Reel, 4000	Green
TPA7252-DF4R (1)	−40 to 125°C	DFN2X2-8	752	3	Tape and Reel, 3000	Green
TPA7252-VS1R (1)	−40 to 125°C	MSOP8	A7252	3	Tape and Reel, 3000	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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