275V Common Voltage Difference Amplifier

Features

- Supply Voltage: 4.5 V to 36 V (±2.25 V to ±18 V)
- Offset Voltage: ±1 mV Maximum
- Gain Error: 0.03% Maximum
- Bandwidth: 500 kHz, Slew Rate: 10 V/μs
- EMI Enhancement
- −40°C to 125°C Operation Temperature Range

Applications

- Current sense on high common voltage
- Battery voltage monitor
- Industrial control

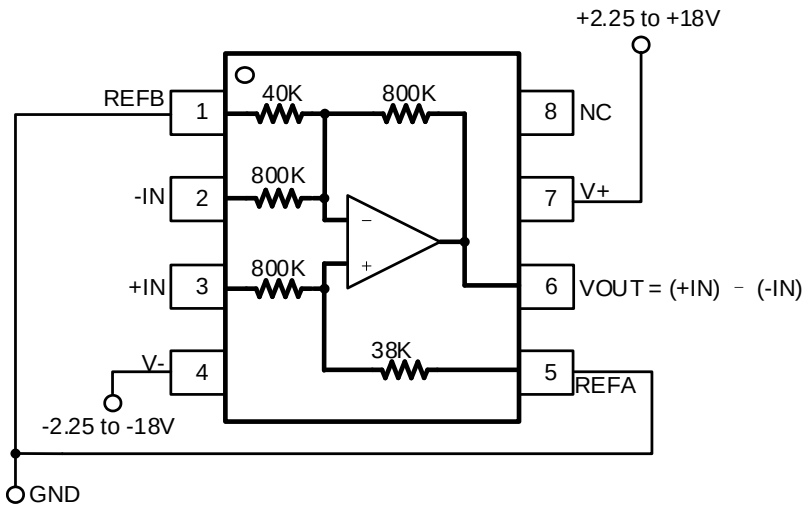
Description

The devices are a general-purpose, unity-gain difference amplifier for precision signal conditioning from −275 V to 275 V common voltage range. The on-chip resistors are trimmed for excellent gain accuracy and high CMRR over the operating temperature range.

The TPA9151 has two reference input pins. The TPA9152 has one reference input pin at pin 1, and left pin 5 to NC(not connect).

The device can be used to replace isolation amplifiers in applications if the galvanic isolation is not required.

Typical Application Circuit



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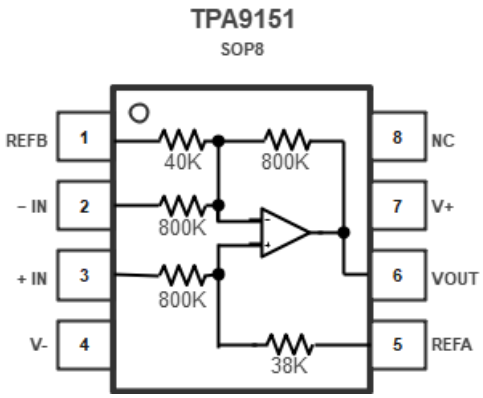
Revision History

Date	Revision	Notes
2021-07-20	Rev.A.0	Initial version.
2021-08-31	Rev.A.1	Updated description in ESD section
2024-01-29	Rev.A.2	Added TPA9152 and TPA9151B.

Pin Configuration and Functions

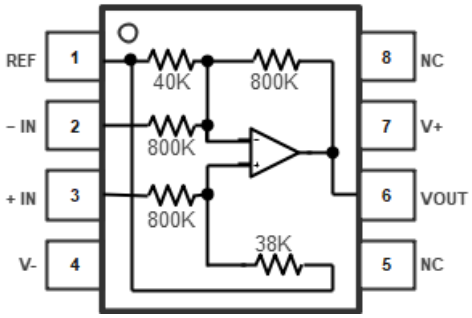


Pin Functions – TPA9151

Pin		I/O	Description
No.	Name		
1	REFB	Input	Reference input B.
2	−IN	Input	Inverting input.
3	+IN	Input	Noninverting input.
4	V−	Power Supply	Negative power supply (1)
5	REFA	Input	Reference input A.
6	VOUT	Output	Output
7	V+	Power Supply	Positive power supply (1)
8	NC		Not Connect.

(1) In this document, (V+) − (V−) is referred to as V_S.

TPA9152
SOP8



Pin Functions – TPA9152

Pin		I/O	Description
No.	Name		
1	REF	Input	Reference input.
2	−IN	Input	Inverting input.
3	+IN	Input	Noninverting input.
4	V−	Power Supply	Negative power supply (1)
5	NC		Not Connect.
6	VOUT	Output	Output
7	V+	Power Supply	Positive power supply (1)
8	NC		Not Connect.

(1) In this document, (V+) − (V−) is referred to as V_S.

Specifications

Absolute Maximum Ratings

Parameter	Min	Max	Unit
Supply Voltage		40	V
Input Voltage Range, Continuous		300	V
Reference Input Voltage	$(-V_S) - 0.3$	$(+V_S) + 0.3$	V
Maximum Operating Junction Temperature		150	°C
Operating Temperature Range	−40	125	°C
Storage Temperature Range	−65	150	°C
Lead Temperature (Soldering, 10 sec)		260	°C

Note: 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.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001(1), VOUT to V+ or V-, V+ to V-	4	kV
		ANSI/ESDA/JEDEC JS-001(1), +IN or –IN to V+ or V-	1	kV
		ANSI/ESDA/JEDEC JS-001(1), REFA	400	V
		ANSI/ESDA/JEDEC JS-001(1), REFB	500	V
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.

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
8-Pin SOIC	158	43	°C/W

Electrical Characteristics

All test condition is (V+) = +15 V and (V−) = −15 V, R_L = 10 kΩ to ground, REFA = REFB = GND, T_A = 25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Power Supply						
V_S	Supply Voltage Range		±2.25		±18	V
I_Q	Quiescent Current	V_{OUT} = 0 V		2	3	mA
		V_{OUT} = 0 V, T_J = −40°C to 125°C			3.5	mA
Gain						
	Initial	V_{OUT} = ±10 V, R_L = 10 kΩ		1		V/V
	Gain Error	V_{OUT} = ±10 V, R_L = 10 kΩ		0.02	0.03	%FSR
		V_{OUT} = ±10 V, R_L = 10 kΩ, T_J = −40°C to 125°C			0.05	%FSR
	Gain Drift	V_{OUT} = ±10 V, R_L = 10 kΩ, T_J = −40°C to 125°C		5		PPM/°C
	Nonlinearity	V_{OUT} = ±10 V, R_L = 10 kΩ		0.002		%FSR
Offset Voltage						
V_{OS}	Input Offset Voltage	V_{CM} = 0 V	–1	0.05	1	mV
		V_{CM} = 0 V, T_J = −40°C to 125°C	–2		2	mV
V_{OS} TC	Offset Voltage Drift	V_{CM} = 0 V, T_J = −40°C to 125°C		2		µV/°C
PSRR	Power Supply Rejection Ratio	V_S = ±2.25 V to ±18 V, V_{CM} = 0 V, V_{DM} = 0 V	90	120		dB
Input						
	Impedance	Differential		1600		kΩ
		Common-mode		400		kΩ
	Voltage Range	Differential	–13.5		13.5	V
		Common-mode, HTOL Test	–200		200	V
CMRR	Common-Mode Rejection Ratio	V_{CM} = ±275 V, Production Test	80	90		dB
		V_{CM} = ±275 V, Production Test, T_J = −40°C to 125°C	78			dB
		V_{CM} = 0 V to 60 V, TPA9151	80	95		dB
		V_{CM} = 0 V to 60 V, TPA9151A	90	96		dB
		V_{CM} = −30 V to 40 V, TPA9151B	96			dB

Electrical Characteristics (Continued)

All test condition is (V+) = +15 V and (V−) = −15 V, R_L = 10 kΩ to ground, REFA = REFB = GND, T_A = 25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Output						
	Output Swing from Supply Rail	R_L = 10 kΩ to V_S/2		50	200	mV
		R_L = 2 kΩ to V_S/2		400	500	mV
I_{SC}	Output Short-Circuit Current			100		mA
AC Specifications						
GBW	Gain-Bandwidth Product			500		kHz
SR	Slew Rate	10 V step		10		V/μs

Typical Performance Characteristics

All test condition: V_S = 30 V, T_A = +25°C, unless otherwise noted.

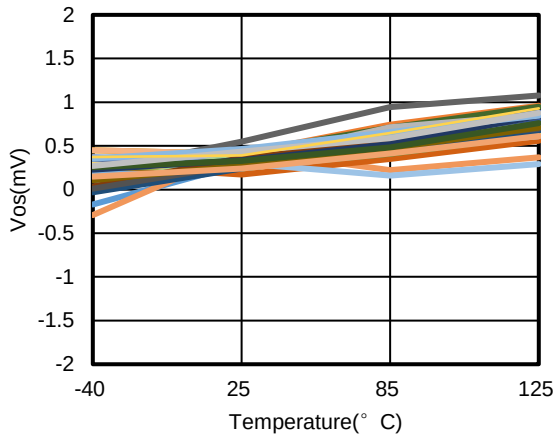


Figure 1 V_{OS} vs Temperature, V_S = 30 V, V_{CM} = 15 V

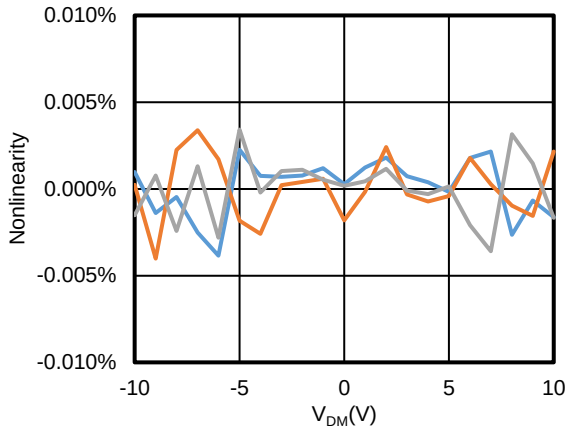


Figure 2 Nonlinearity

Detailed Description

Overview

The TPA9151 and TPA9152 integrate on-chip matching resistors with high precision amplifier to achieve excellent gain accuracy, linearity and CMRR over the operating temperature range. The resistors also extend the input signal range beyond the power supply rail.

Functional Block Diagram

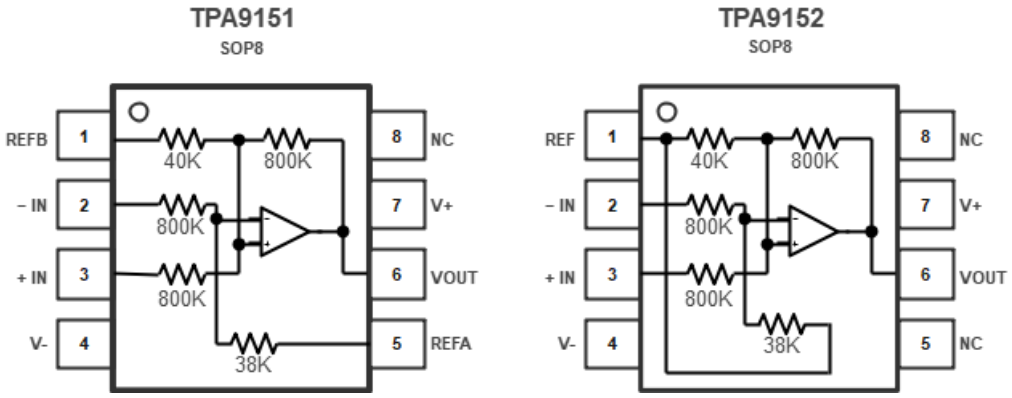


Figure 3 Functional Block Diagram

Application and Implementation

NOTE

Information in the following applications 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.

Transfer Function

The complete transfer function of TPA9151 is given in Equation (1).

$$VOUT = (+IN) - (-IN) + 20 \times REFA - 19 \times REFB \quad (1)$$

Usually, REFA and REFB are tied to the same voltage level, and recorded as REF, so the transfer function is Equation (2). REFA and REFB are tied to pin 1 internal in TPA9152.

$$VOUT = (+IN) - (-IN) + REF \quad (2)$$

Basic Connections

Figure 4 Dual Supply Operation Connections shows the basic connections for dual-supply operation. Figure 5 shows the basic connections for single-supply operation. 0.1 μF decoupling capacitors are recommended to be placed close to the power supply pins of the device.

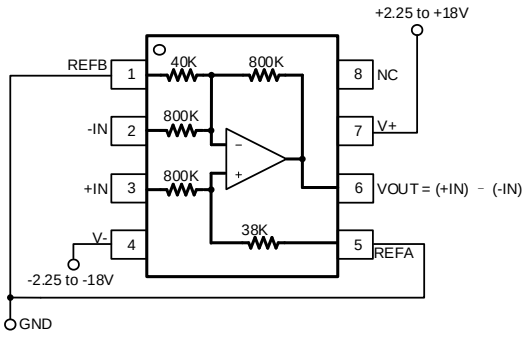


Figure 4 Dual Supply Operation Connections

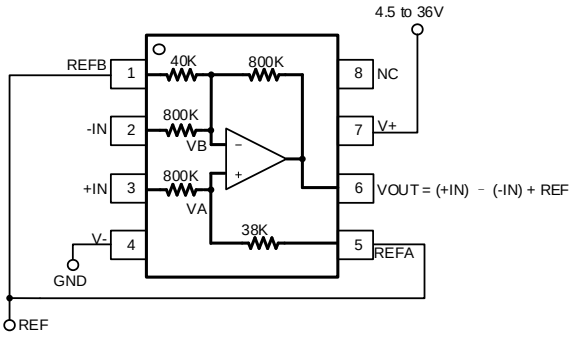


Figure 5 Single Supply Operation Connections

Common Mode Input Range

The high common-mode range of the device is achieved by dividing down the input signal with resistor divider. This resistor divider brings both the positive input (+IN) and the negative input (−IN) within the input range of the internal operational amplifier. VA and VB are the inputs of internal operational amplifier in Figure 5, which can be calculated by the voltage at the (−IN), (+IN), REFA, REFB, (V+) and (V−) pin when the device works in the close loop. VA and VB can swing to negative power rail and 1.5V less than positive power rail, so the common-mode input range at the (+IN) input can be calculated by the Equation (3),

$$V_{CM} = (800+38)/38 \times (VA \text{ or } VB) - 800/38 \times REFA \cong 22 \times (VA \text{ or } VB) - 21 \times REFA \quad (3)$$

Some calculated cases are shown in Table 1, and please note that +275 V to −275 V voltage range is guaranteed by production test, +200 V to −200 V voltage range is guaranteed by HTOL test.

Table 1 Common voltage range with different supply voltage and reference voltage

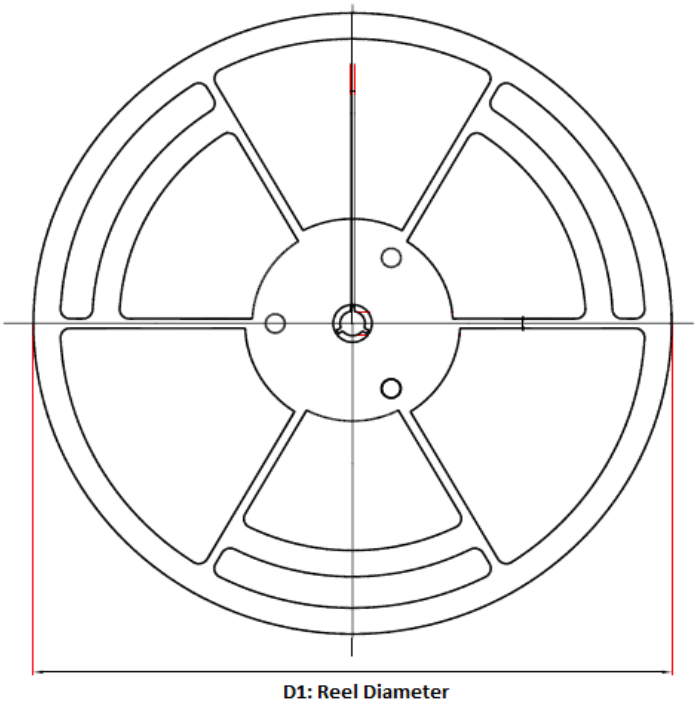
V+	V–	REFA	VA or VB		V_{CM}	
			Min	Max	Min	Max
15	–15	0	−15	13.5	−330	297
30	0	15	0	28.5	−315	312
10	–10	0	−10	8.5	−220	187
10	0	5	0	8.5	−105	82

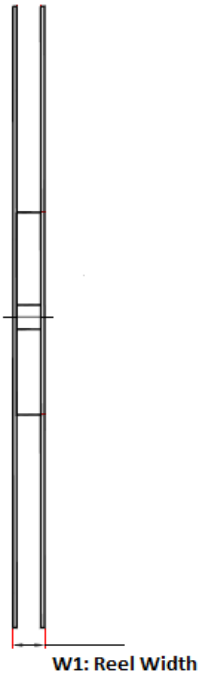
Differential Input Range

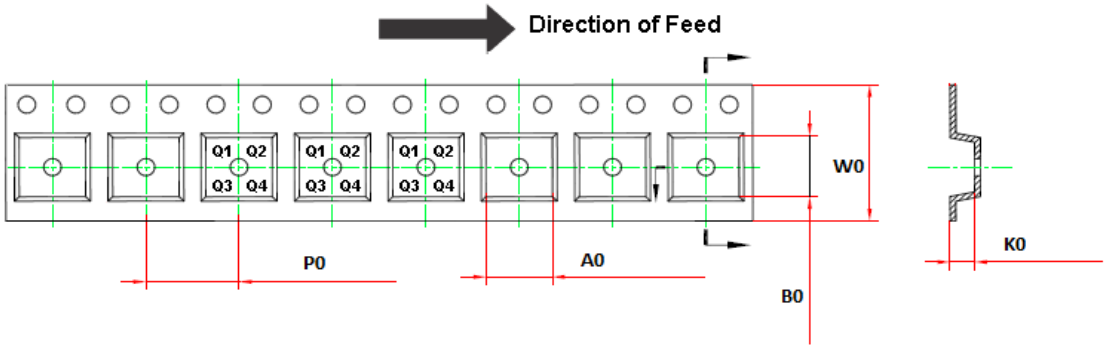
When the voltage at the (+IN) pin is within the range calculated by the Equation (3), the voltage at the (–IN) pin can be determined by VOUT, REFA, REFB from Equation (4) which is derived from Equation (2). VOUT must be kept in the output range of internal amplifier. VOUT can reach negative and positive power rails.

$$(-IN) = (+IN) - VOUT + REF \quad (4)$$

Tape and Reel Information





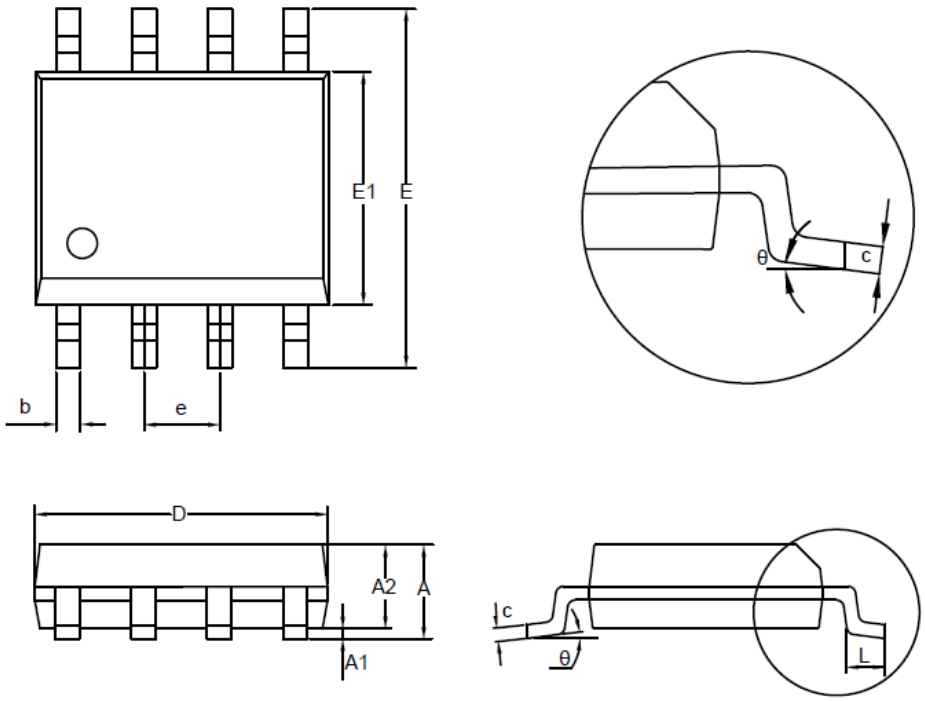


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA9151-SO1R	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA9151A-SO1R	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA9152-SO1R	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1

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
TPA9151-SO1R	−40 to 125°C	SOP8	A9151	3	Tape and Reel, 4000
TPA9151A-SO1R	−40 to 125°C	SOP8	A9151	3	Tape and Reel, 4000
TPA9151B-SO1R	−40 to 125°C	SOP8	A9151	3	Tape and Reel, 4000
TPA9152-SO1R	−40 to 125°C	SOP8	A9152	3	Tape and Reel, 4000

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