5-V, Rail-to-Rail Input/Output, 6-MHz Op Amp

Features

- Supply Voltage: 2.5 V to 5.5 V
- No Oscillation when Driving Large Capacitor Loads: Up to 10 µF
- Offset Voltage: ±3 mV Maximum
- Bandwidth: 6 MHz, Slew Rate: 5 V/µs
- Low Power: 0.8 mA per Channel
- Rail-to-Rail Input and Output
- Low 1/f Noise: 25 nV/√Hz at 1 kHz
- –40°C to 125°C Operation Temperature Range

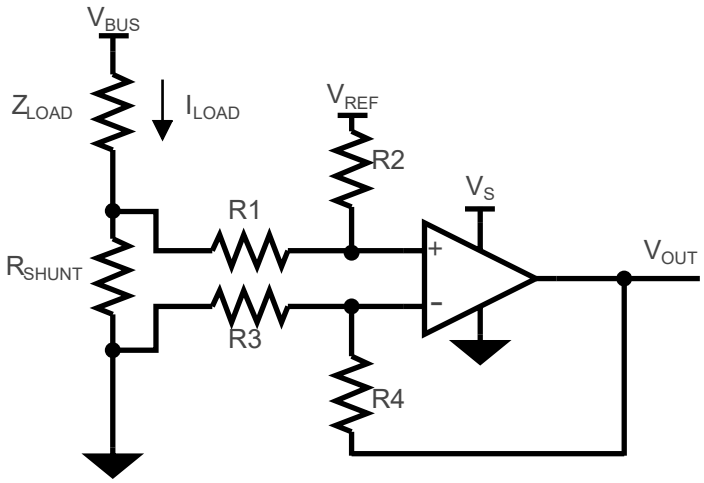
Applications

- Instrumentation
- Motor Control
- Industrial Control

Description

The devices are CMOS RRIO op-amps with low offset, low power, and stable high-frequency response. They incorporate proprietary and patented design techniques to achieve high-performance AC with 6-MHz bandwidth, 5-V/µs slew rate, and low distortion while drawing only 0.8 mA of quiescent current per amplifier. The devices are suitable for audio and motor control applications.

Typical Application Circuit



$V_{OUT} = (I_{LOAD} \times R_{SHUNT}) \times (R2 / R1) + V_{REF}$

When R3 = R1, R2 = R4, $R_{SHUNT} << R1$

Table of Contents

Features **1**
Applications **1**
Description **1**
Typical Application Circuit **1**
Revision History **3**
Pin Configuration and Functions **4**
Specifications **7**
Absolute Maximum Ratings 7
ESD, Electrostatic Discharge Protection 7
Recommended Operating Conditions 7
Thermal Information 7
Electrical Characteristics 9
Electrical Characteristics (Continued) 10
Typical Performance Characteristics 11
Detailed Description **14**
Overview 14
Functional Block Diagram 14
Feature Description 15
Tape and Reel Information **16**
Package Outline Dimensions **17**
SOT23-5 17
SOP8 18
MSOP8 19
SOP14 20
TSSOP14 21
Order Information **22**
IMPORTANT NOTICE AND DISCLAIMER **23**

Revision History

Date	Revision	Notes
2024-11-20	Rev.A.0	Initial release.

Pin Configuration and Functions

TPA6061
SOT23-5
Top View

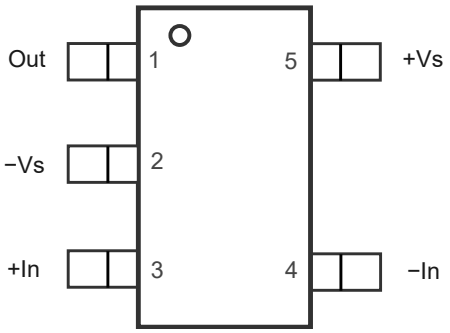
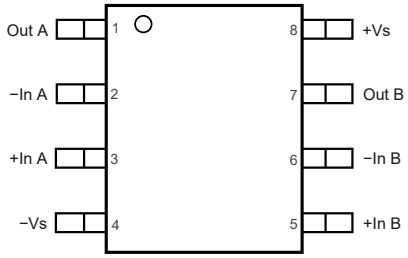


Table 1. Pin Functions: TPA6061

Pin No. SOT23-5	Name	I/O	Description
1	Out	O	Output
2	$-V_S$		Negative power supply
3	+In	I	Non-inverting input
4	−In	I	Inverting input
5	$+V_S$		Positive power supply

TPA6062
SOP8
Top View



TPA6062
MSOP8
Top View

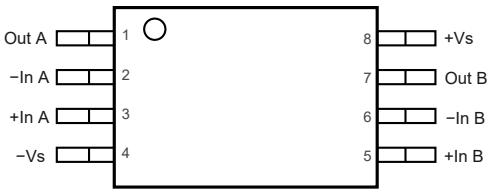
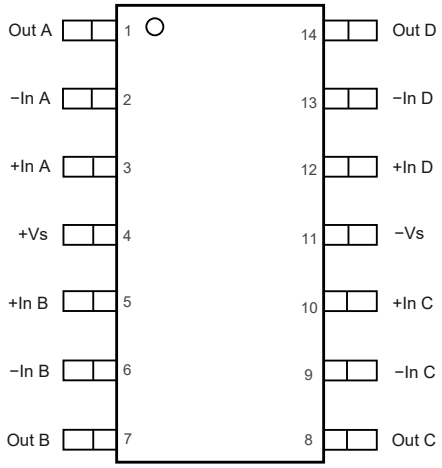


Table 2. Pin Functions: TPA6062

Pin No.		Name	I/O	Description
SOP8	MSOP8			
1	1	Out A	O	Output
2	2	−In A	I	Inverting input
3	3	+In A	I	Non-inverting input
4	4	$-V_S$		Negative power supply
5	5	+In B	I	Non-inverting input
6	6	−In B	I	Inverting input
7	7	Out B	O	Output
8	8	$+V_S$		Positive power supply

TPA6064
SOP14
Top View



TPA6064
TSSOP14
Top View

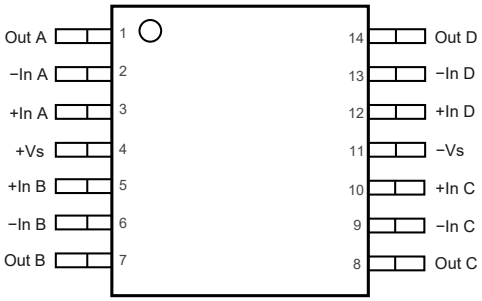


Table 3. Pin Functions: TPA6064

Pin No.		Name	I/O	Description
SOP14	TSSOP14			
1	1	Out A	O	Output
2	2	−In A	I	Inverting input
3	3	+In A	I	Non-inverting input
4	4	$+V_S$		Positive power supply
5	5	+In B	I	Non-inverting input
6	6	−In B	I	Inverting input
7	7	Out B	O	Output
8	8	Out C	O	Output
9	9	−In C	I	Inverting input
10	10	+In C	I	Non-inverting input
11	11	$-V_S$		Negative power supply
12	12	+In D	I	Non-inverting input
13	13	−In D	I	Inverting input
14	14	Out D	O	Output

Specifications

Absolute Maximum Ratings

Over operating ambient temperature (unless otherwise noted) (1)

Parameter		Min	Max	Unit
	Supply Voltage, $(+V_S) – (–V_S)$		6.5	V
	Input Voltage	$(-V_S) – 0.3$	$(+V_S) + 0.5$	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

Parameter		Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 (1)	6	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	Supply Voltage, $(+V_S) – (-V_S)$	2.5		5.5	V
T_A	Operating Temperature Range	–40		125	°C

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOT23-5	250	81	°C/W

Package Type	θ_{JA}	θ_{JC}	Unit
SOP8	158	43	°C/W
MSOP8	210	45	°C/W
SOP14	120	36	°C/W
TSSOP14	180	35	°C/W

Electrical Characteristics

All test conditions: V_S = 5 V, T_A = 25°C, R_L = 10 kΩ, unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
Power Supply						
V_S	Supply Voltage Range		2.5		5.5	V
I_Q	Quiescent Current per Amplifier			0.8	1	mA
		T_A = −40°C to 125°C			1.2	mA
PSRR	Power Supply Rejection Ratio	V_S = 2.5 V to 5.5 V, V_{CM} = 1 V	72	94		dB
		V_S = 2.5 V to 5.5 V, V_{CM} = 1 V , T_A = −40°C to 125°C	60			dB
Input Characteristics						
V_{OS}	Input Offset Voltage	V_{CM} = 0 V to 2.5 V	−3	1.5	3	mV
		V_{CM} = 0 V to 2.5 V, T_A = −40°C to 125°C	−3.5		3.5	mV
		V_{CM} = 3.5 V to 5 V	-6.8	1.8	6.8	mV
		V_{CM} = 3.5 V to 5 V, T_A = −40°C to 125°C	-11		11	mV
V_{OS} TC	Input Offset Voltage Drift	V_{CM} = 0 V to 2.5 V, T_A = −40°C to 125°C		1		μV/°C
		V_{CM} = 3.5 V to 5 V, T_A = −40°C to 125°C		2		μV/°C
I_B	Input Bias Current (1)	V_{CM} = 2.5 V	-300	10	300	pA
		V_{CM} = 2.5 V, T_A = −40°C to 125°C	-5		5	nA
I_{OS}	Input Offset Current (1)	V_{CM} = 2.5 V	-300	10	300	pA
		V_{CM} = 2.5 V, T_A = −40°C to 125°C	-5		5	nA
C_{IN}	Input Capacitance (2)	Differential Mode		6		pF
		Common Mode		8		pF
Av	Open−loop Voltage Gain	V_O = 1 V to 4 V	85	100		dB
		V_O = 1 V to 4 V, T_A = −40°C to 125°C	80			dB
V_{CMR}	Common−mode Input Voltage Range	T_A = −40°C to 125°C	(−V_S)− 0.1		(+V_S)+ 0.1	V
CMRR	Common-mode Rejection Ratio	V_{CM} = 0 V to 3 V	80	105		dB
		V_{CM} = 0 V to 3 V, T_A = −40°C to 125°C	75			dB
		V_{CM} = 0 V to 5 V	60	80		dB
		V_{CM} = 0 V to 5 V, T_A = −40°C to 125°C	55			dB
Output Characteristics						
	Output Voltage Swing from Positive Rail or Negative Rail	R_L = 10 kΩ to V_S/2		10	15	mV
		R_L = 10 kΩ to V_S/2, T_A = −40°C to 125°C			20	mV

Electrical Characteristics (Continued)

All test conditions: V_S = 5 V, T_A = 25°C, R_L = 10 kΩ, unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
I_{SC}	Output Short−Circuit Current	Sink or Source	70	90		mA
		Sink or Source, TA = −40°C to 125°C	50			mA
AC Specifications						
GBW	Gain−Bandwidth Product			6		MHz
SR	Slew Rate	G = 1, 2 V step, T_A = −40°C to 125°C	3	5		V/μs
t_{OR}	Overload Recovery			200		ns
t_S	Settling Time, 0.1%	G = 1, 2 V step		900		ns
	Settling Time, 0.01%	G = 1, 2 V step		1200		ns
PM	Phase Margin	R_L= 10 kΩ, C_L= 100 pF		70		°
GM	Gain Margin	R_L= 10 kΩ, C_L= 100 pF		10		dB
	Channel Separation	f = 100 kHz		120		dB
Noise Performance						
E_N	Input Voltage Noise	f = 0.1 Hz to 10 Hz,		2.1		μV_{RMS}
e_N	Input Voltage Noise Density	f = 1 kHz		25		nV/√Hz
i_N	Input Current Noise	f = 1 kHz		20		fA/√Hz
THD+N	Total Harmonic Distortion and Noise	f = 1 kHz, G = 1, R_L = 10 kΩ, V_{OUT} = 1 V_{RMS}		0.002		%

(1) Provided by bench test and design simulation.
(2) Provided by design simulation.

Typical Performance Characteristics

All test conditions: V_S = 5 V, V_{CM} = 2.5 V, unless otherwise noted.

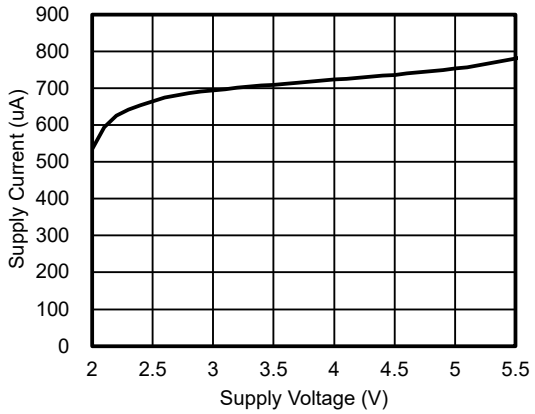


Figure 1. Supply Current vs Supply Voltage

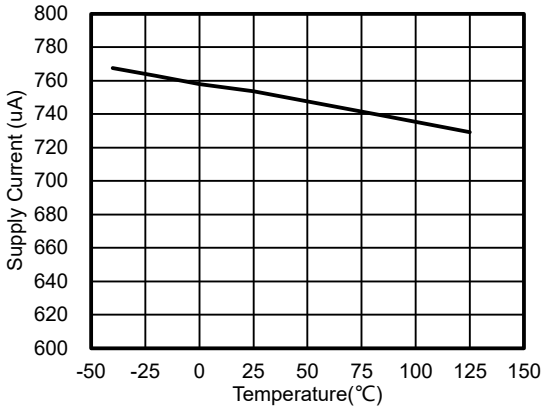


Figure 2. Supply Current vs Temperature

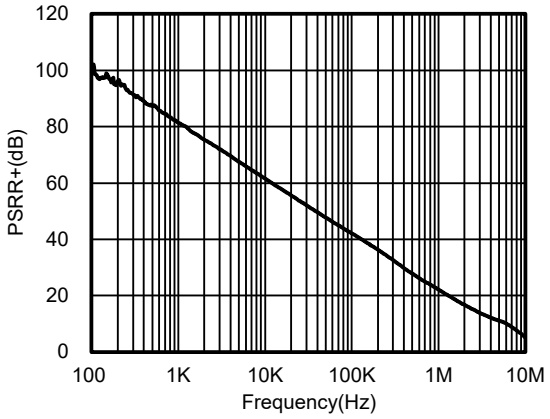


Figure 3. PSRR+ vs Frequency

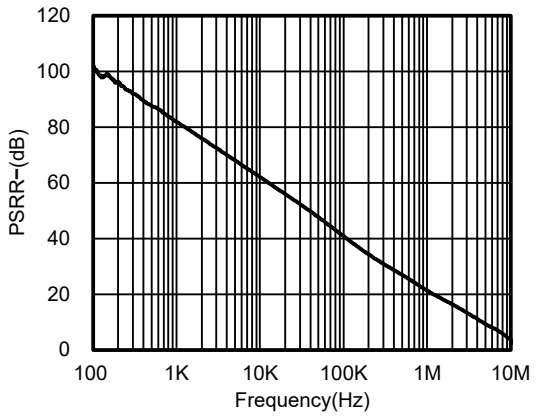


Figure 4. PSRR− vs Frequency

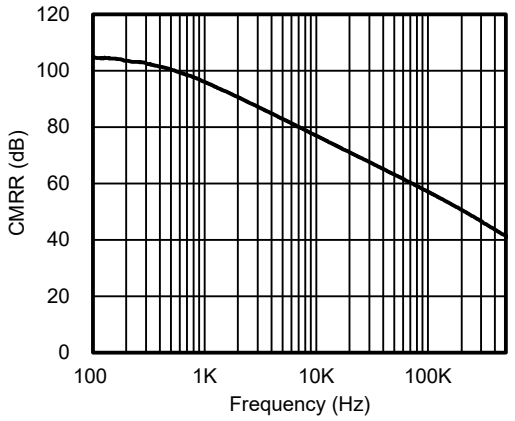


Figure 5. CMRR vs Frequency

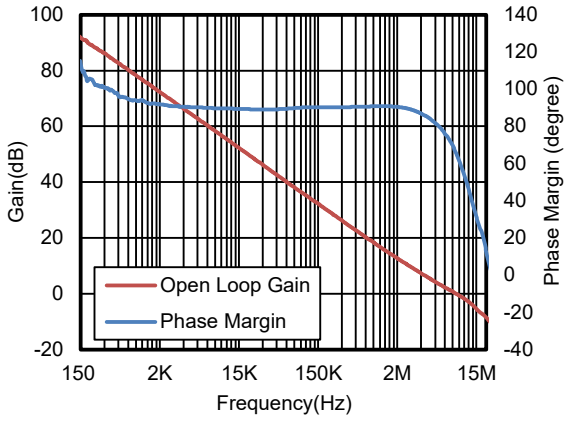


Figure 6. Open Loop Gain and Phase Margin vs Frequency, RL = 10 kΩ

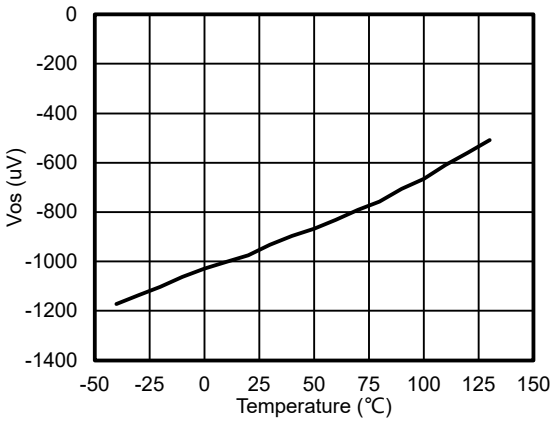


Figure 7. V_{OS} vs Temperature

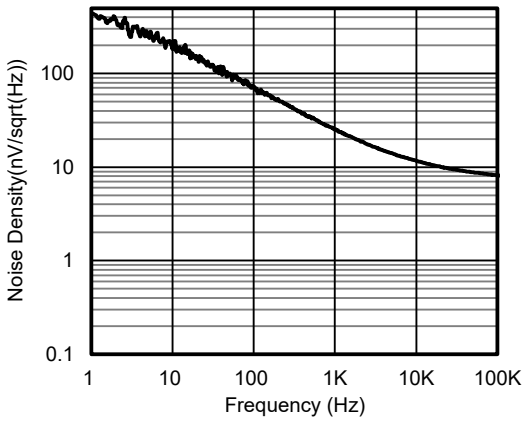


Figure 8. Voltage Noise Spectral Density vs Frequency

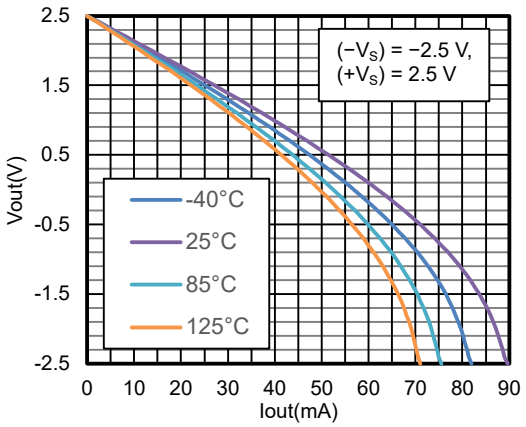


Figure 9. Output Voltage vs Output Current

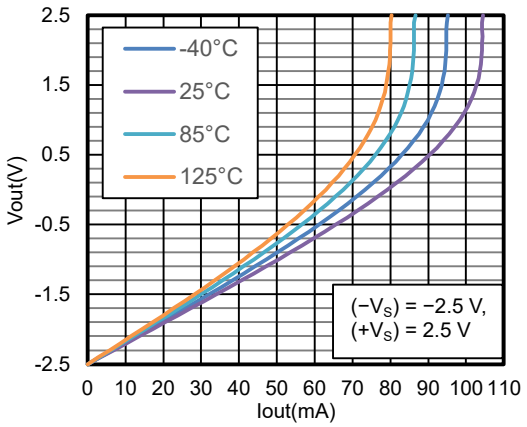


Figure 10. Output Voltage vs Output Current

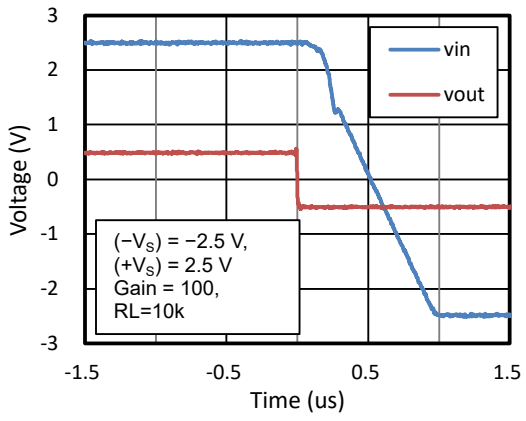


Figure 11. Overload Recovery at Negative Rail

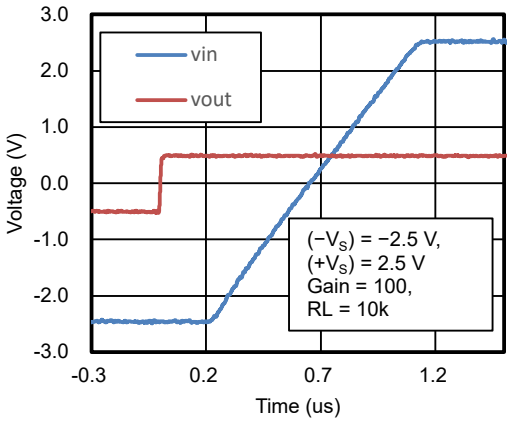


Figure 12. Overload Recovery at Positive Rail

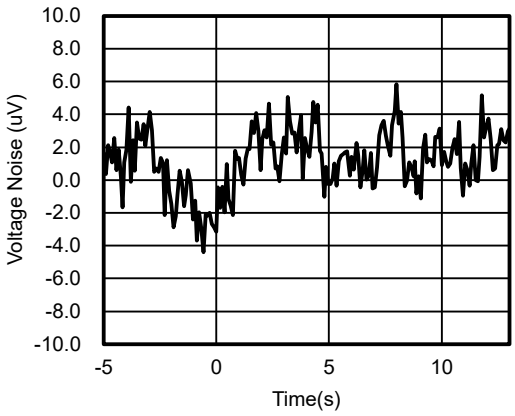


Figure 13. 0.1 to 10 Hz Voltage Noise

Detailed Description

Overview

The devices are a family of low-power, rail-to-rail output operational amplifiers. These devices operate from 2.5 V to 5.5 V, and are designed for a wide range of general-purpose applications.

Functional Block Diagram

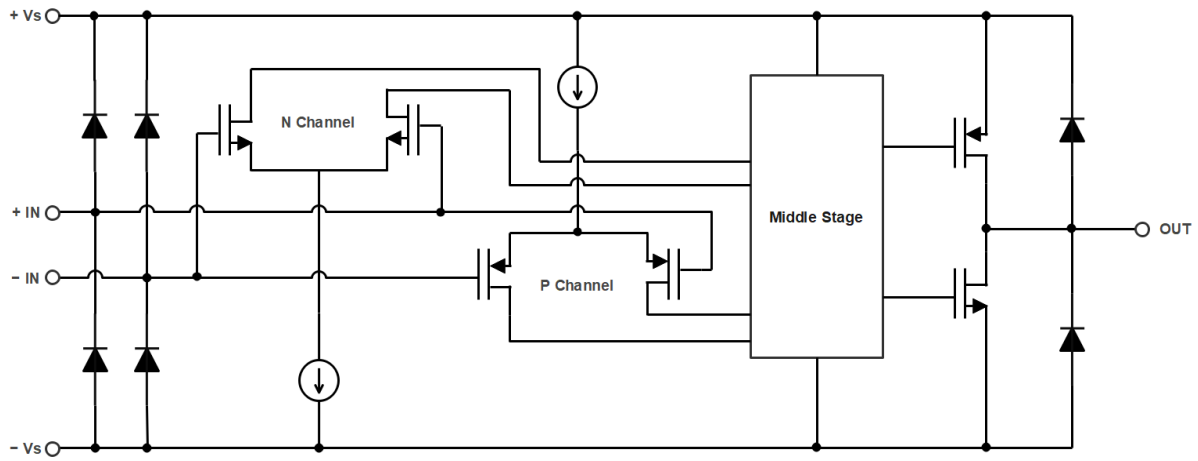


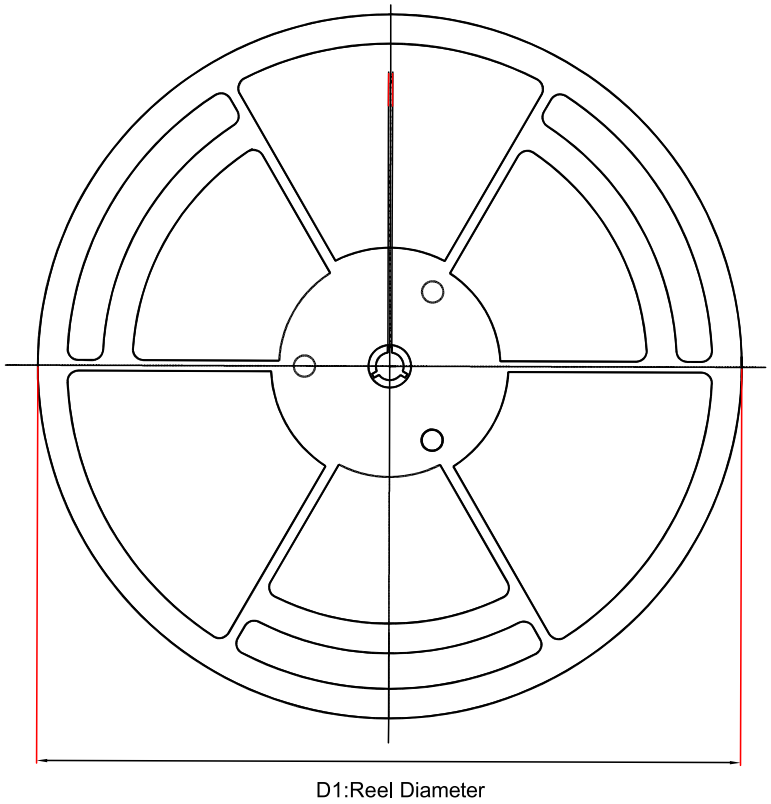
Figure 14. Functional Block Diagram

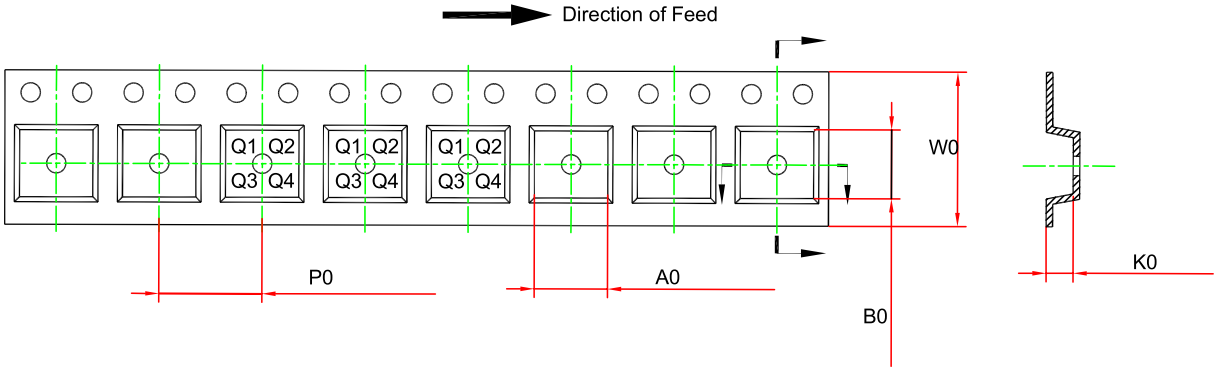
Feature Description

Drive Large Capacitive Loads

Driving capacitive loads has always been a difficult part of the amplifier circuit design, and the devices are designed with a special architecture that prevents it from sustaining oscillations when the output is driving large capacitive loads up to 10 μF.

Tape and Reel Information



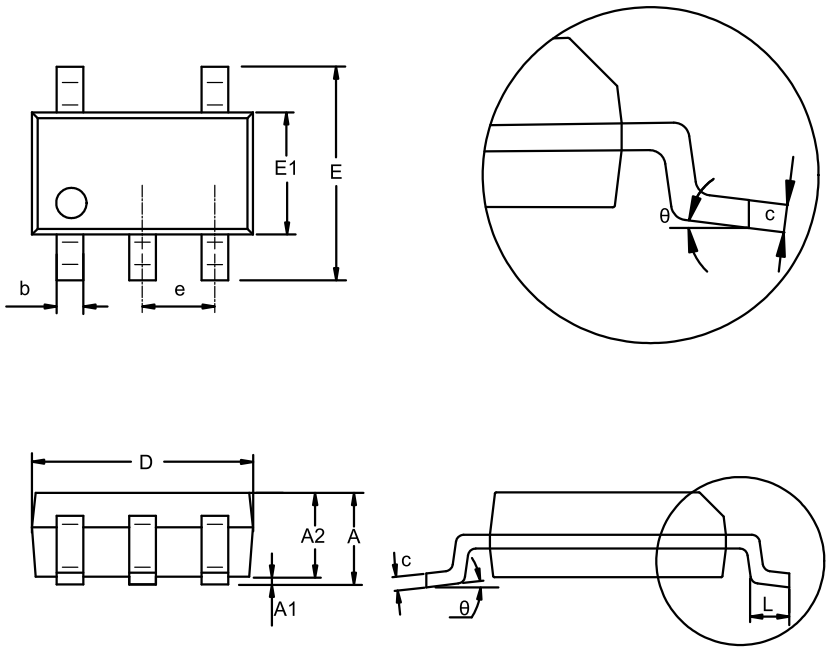


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA6061-S5TR	SOT23-5	180.0	12	3.3	3.3	1.4	4.0	8.0	Q3
TPA6062-SO1R	SOP8	330.0	17.6	6.5	5.4	2.0	8.0	12.0	Q1
TPA6062-VS1R	MSOP8	330.0	17.6	5.3	3.4	1.3	8.0	12.0	Q1
TPA6064-SO2R	SOP14	330.0	21.6	6.5	9.2	1.8	8.0	16.0	Q1
TPA6064-TS2R	TSSOP14	330.0	17.6	6.8	5.5	1.3	8.0	12.0	Q1

Package Outline Dimensions

SOT23-5

Package Outline Dimensions S5T(SOT23-5-B)



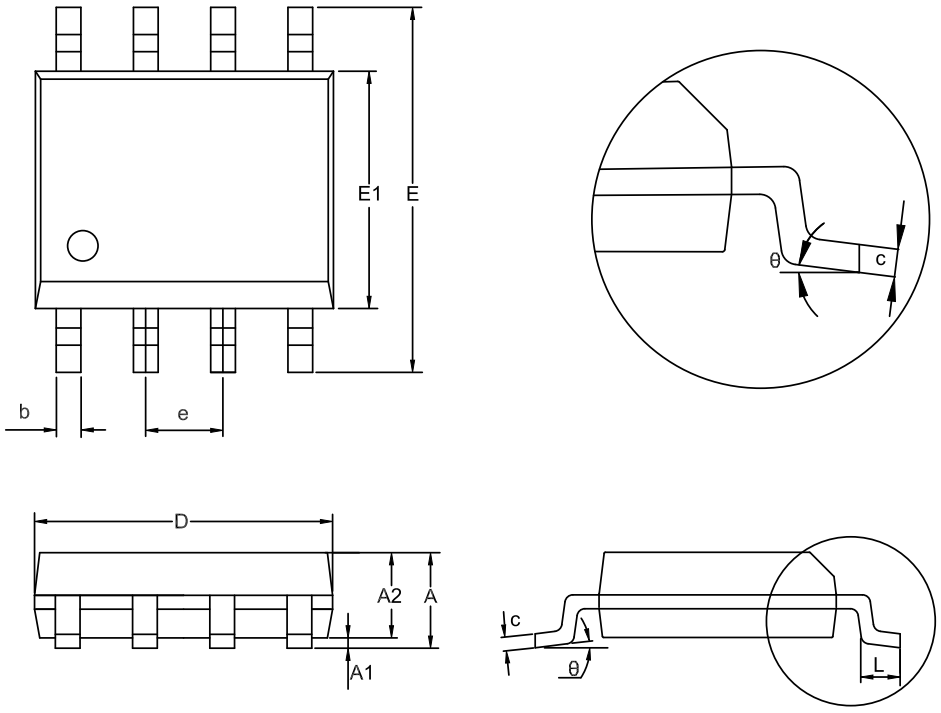
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.000	1.200	0.039	0.047
b	0.330	0.410	0.013	0.016
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037 BSC	
L	0.300	0.600	0.012	0.024
θ	0	8°	0	8°

NOTES

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

SOP8

Package Outline Dimensions SO1(SOP-8-A)



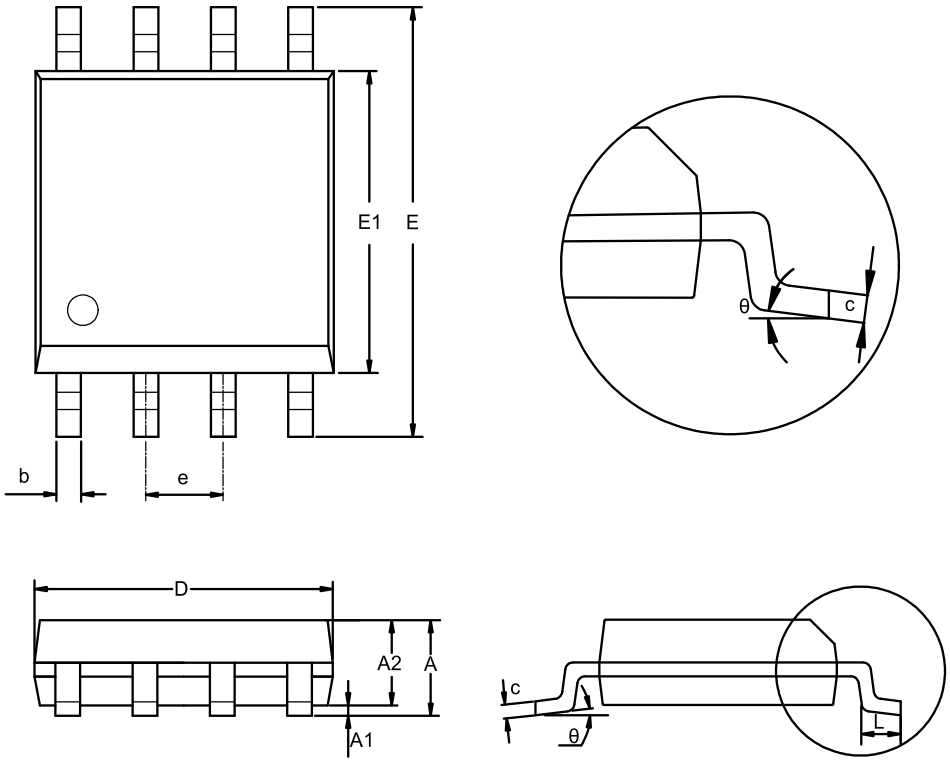
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050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



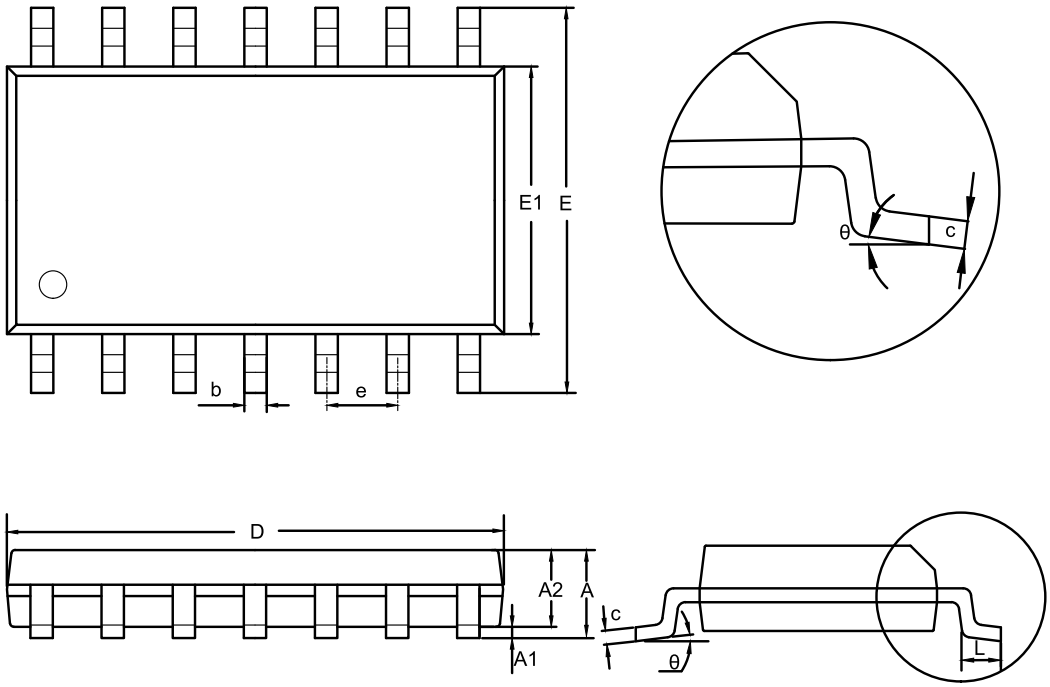
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026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

SOP14

Package Outline Dimensions SO2(SOP-14-A)



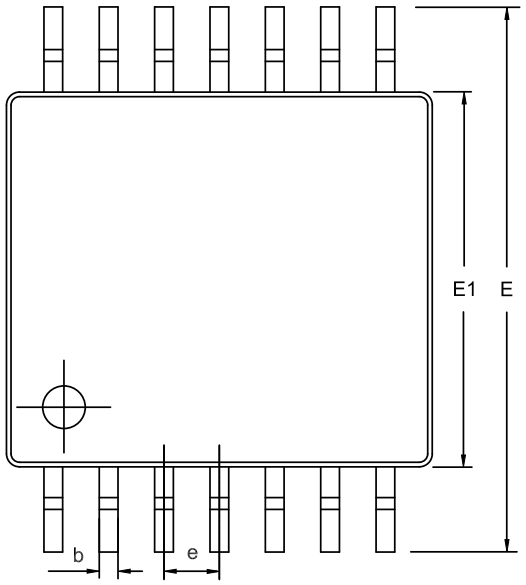
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.650	0.049	0.065
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	8.450	8.850	0.333	0.348
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0	8°	0	8°

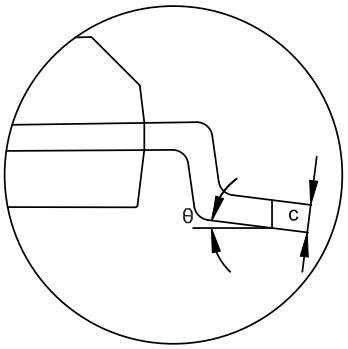
NOTES

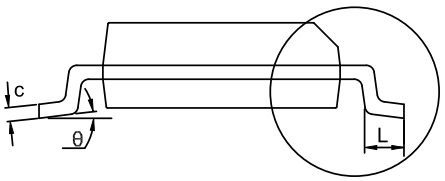
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

TSSOP14

Package Outline Dimensions — TS2(TSSOP-14-A)







Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.200	0.035	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.900	5.100	0.193	0.201
E	6.200	6.600	0.244	0.260
E1	4.300	4.500	0.169	0.177
e	0.650 BSC		0.026 BSC	
L	0.450	0.750	0.018	0.030
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
TPA6061-S5TR (1)	−40 to 125°C	SOT23-5	AA0	1	Tape and Reel, 3000	Green
TPA6062-SO1R	−40 to 125°C	SOP8	A6062	3	Tape and Reel, 4000	Green
TPA6062-VS1R	−40 to 125°C	MSOP8	A6062	2	Tape and Reel, 3000	Green
TPA6064-SO2R(1)	−40 to 125°C	SOP14	A6064	3	Tape and Reel, 2500	Green
TPA6064-TS2R(1)	−40 to 125°C	TSSOP14	A6064	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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