1.4-V Ultra Low Voltage, 13-μA Micro-Power RRIO Op Amps

Features

- Ultra Low Supply Voltage: 1.4 V to 5.5 V
- Low Quiescent Current: 13 μA/ch
- Gain Bandwidth Product: 240 kHz
- Offset Voltage Range: ±3.1 mV at 25°C
- Rail-to-Rail Input and Output
- Unit-Gain Stable
- Slew Rate: 0.13 V/μs
- Operating Temperature Range: −40°C to 85°C

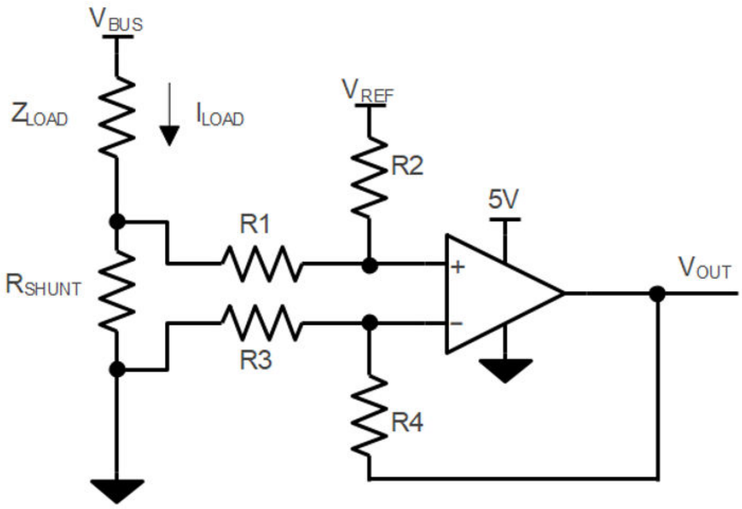
Applications

- Portable Electronic Devices
- Wearable Electronic Devices
- IOT Devices

Description

The TPA611x are op-amps with rail-to-rail input and output. Besides, the device features micro quiescent current (13 μA, typ.) and ultra-low operating supply voltage (1.4 V to 5.5 V). Thus, the device is suitable for battery-powered devices, such as IOT devices, wearable devices, and other devices, in which both low operating voltage and low quiescent current are crucial. Further, the TPA6111 and TPA6112 offer space-saving package (DFN0.8×0.8 and DFN2×2), which make these more suitable for highly integrated devices.

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

Revision History

Date	Revision	Notes
2026-01-25	Rev.A.0	Initial version.

Pin Configuration and Functions

TPA6111
DFN0.8×0.8-4 (5 Pin)
Top View

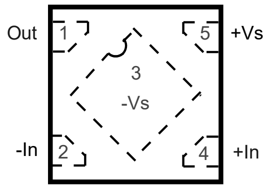


Table 1. Pin Functions: TPA6111

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

TPA6112
DFN2x2-8
Top View

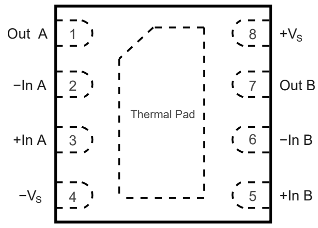


Table 2. Pin Functions: TPA6112

Pin No.	Name	I/O	Description
1	Out A	O	Output
2	−In A	I	Inverting input
3	+In A	I	Non-inverting input
4	$-V_S$		Negative power supply
5	+In B	I	Non-inverting input
6	−In B	I	Inverting input
7	Out B	O	Output
8	$+V_S$		Positive power supply
	Thermal Pad		The thermal pad of DFN or QFN package is recommended to be left float or connected to $-V_S$.

Specifications

Absolute Maximum Ratings (1)

All test conditions: over the operating ambient temperature, unless otherwise noted.

Parameter		Min	Max	Unit
	Supply Voltage, $(+V_S) - (-V_S)$		6.5	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 the 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. The 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)	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.

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V_S	Supply Voltage, $(+V_S) - (-V_S)$	1.4		5.5	V
T_A	Operating Temperature Range	−40		85	°C

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
DFN0.8×0.8-4 (5 Pin)	500	200	°C/W
DFN2×2-8	100	60	°C/W

Electrical Characteristics

All test conditions: V_S = 5.5 V, V_{OUT}= 2.75 V, T_A= 25 °C, R_L= 10 kΩ, C_L= 100 pF, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Power Supply						
V_S	Supply Voltage Range		1.4		5.5	V
I_Q	Quiescent Current per Amplifier	V_S = 1.4 V to 5.5 V		13	20	μA
		V_S = 1.4 V to 5.5 V, T_A = −40°C to 85°C			23	μA
PSRR	Power Supply Rejection Ratio	V_S = 1.6 V to 5.5 V, V_{CM} = 0 V	71	93		dB
		V_S = 1.6 V to 5.5 V, V_{CM} = 0 V T_A = −40°C to 85°C	67			dB
Input Characteristics						
V_{OS}	Input Offset Voltage	V_S = 5.5 V, V_{CM} = 2.75 V	−3.1	±0.8	3.1	mV
		V_S = 5.5 V, V_{CM} = 2.75 V T_A = −40°C to 85°C	−3.5		3.5	mV
		V_S = 1.4 V, V_{CM} = 0.7 V	−3.5	±1	3.5	mV
		V_S = 1.4 V, V_{CM} = 0.7 V T_A= −40°C to 85°C	−4.5		4.5	mV
	Input Offset Voltage Drift	V_S = 5.5 V, V_{CM} = 2.75 V T_A = −40°C to 85°C		2		μV/°C
I_B	Input Bias Current	V_{CM} = 2.75 V		10		pA
I_{OS}	Input Offset Current	V_{CM} = 2.75 V		10		pA
C_{IN}	Input Capacitance	Differential Mode		2		pF
		Common Mode		4		pF
A_{OL}	Open-Loop Voltage Gain	V_S = 5.5 V, $(V_-) + 0.1\ V < V_O < (V_+) - 0.1\ V$, R_L = 100 kΩ to V_S / 2	90	126		dB
		V_S = 5.5 V, $(V_-) + 0.1\ V < V_O < (V_+) - 0.1\ V$, R_L = 100 kΩ to V_S / 2 T_A = −40°C to 85°C	85			dB
V_{CMR}	Common-mode Input Voltage Range	T_A = −40°C to 85°C	$(-V_S)$		$(+V_S)$	V
CMRR	Common-mode Rejection Ratio	V_S = 5.5 V, V_{CM} = 0 V to 5.5 V	55	80		dB
		V_S = 5.5 V, V_{CM} = 0 V to 5.5 V, T_A = −40°C to 85°C	50			dB
Output Characteristics						
	Output Voltage Swing from Power Rail	V_S = 5.5 V, R_L = 100 kΩ to V_S/ 2		2	5	mV
		V_S = 5.5V, R_L = 100 kΩ to V_S/ 2, T_A = −40°C to 85°C			10	mV
		V_S = 5.5 V, R_L = 10 kΩ to V_S/ 2		10	20	mV

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		V_S = 5.5 V, R_L = 10 kΩ to V_S/ 2, T_A = −40°C to 85°C			25	mV
I_{SC}	Output Short-Circuit Current	Sink current		60		mA
		Source current		50		mA
AC Specifications						
GBW	Gain-Bandwidth Product	V_S = 5 V		240		kHz
SR	Slew Rate	V_S = 5 V, G = 1, 2 V Step		0.13		V/μs
Z_O	Z_{OUT}	V_S = 5 V, f =10 kHz		7500		Ω
t_{OR}	Overload Recovery	V_S = 5 V		26		μs
t_S	Settling Time, 0.1%	V_S = 5 V, G = 1, 2 V Step		80		μs
PM	Phase Margin	V_S = 5 V, R_L = 10 kΩ, C_L = 100 pF		45		°
	Channel Separation	V_S = 5 V, f = 100 kHz		110		dB
Noise Performance						
E_N	Input Voltage Noise	V_S = 5 V, f = 0.1 Hz to 10 Hz		20		μV_{VPP}
e_N	Input Voltage Noise Density	V_S = 5 V, f = 0.1 kHz		130		$nV/\sqrt{Hz}$
e_N	Input Voltage Noise Density	V_S = 5 V, f = 1 kHz		60		$nV/\sqrt{Hz}$
THD+N	Total Harmonic Distortion and Noise	V_S = 5 V, f = 1 kHz, G = 1, R_L = 10 kΩ, V_{OUT} = 1 V_{RMS}		0.02		%

Typical Performance Characteristics

All test conditions: V_S = 5 V, T_A = +25℃, unless otherwise noted.

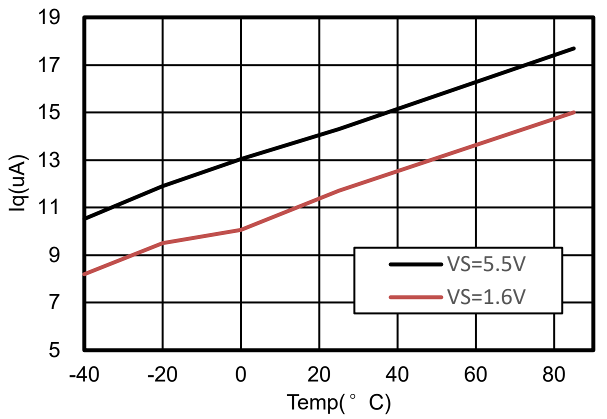


Figure 1. Quiescent Current vs. Temperature

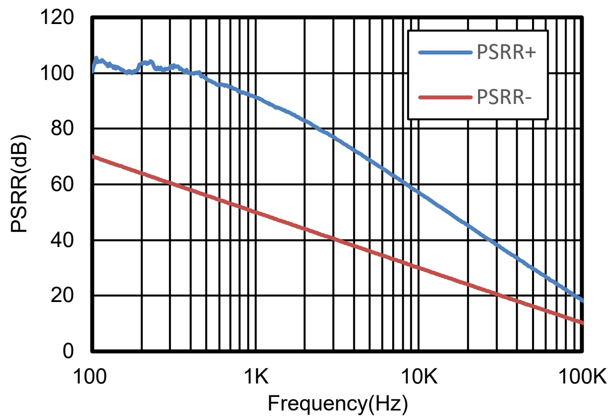


Figure 2. PSRR vs. Frequency

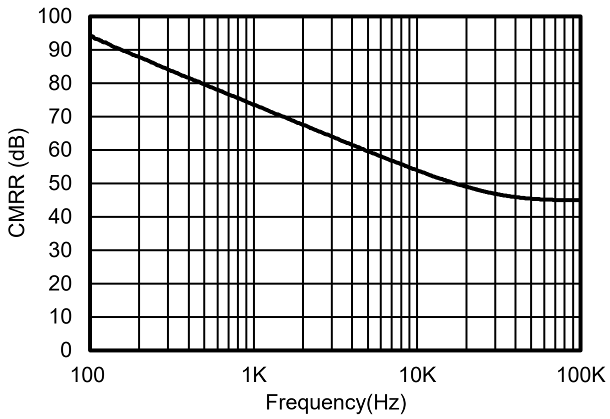


Figure 3. CMRR vs. Frequency

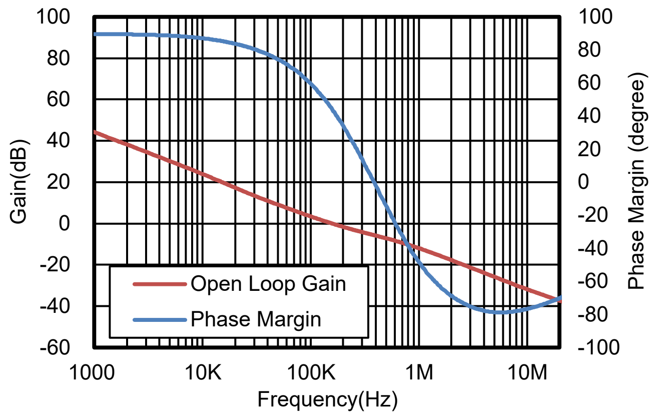


Figure 4. Open-Loop Gain and Phase Margin vs. Frequency, R_L = 10 kΩ, C_L = 100 pF

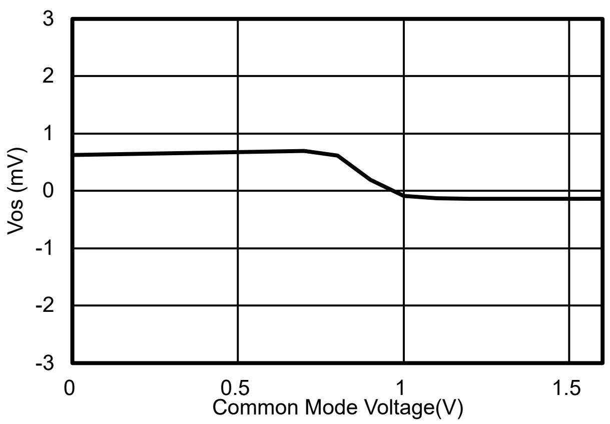


Figure 5. V_{OS} vs. V_{CM}, V_S = 1.6 V

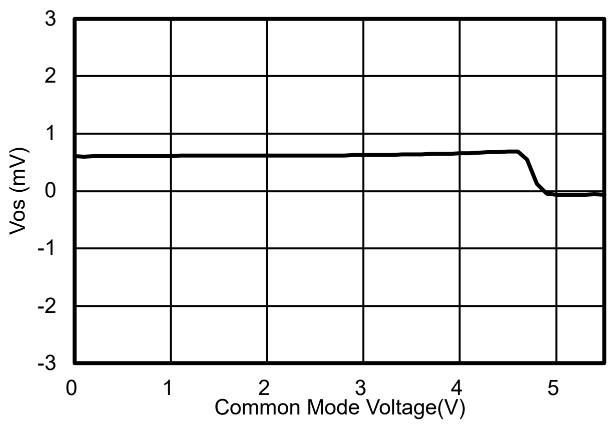


Figure 6. V_{OS} vs. V_{CM}, V_S = 5.5 V

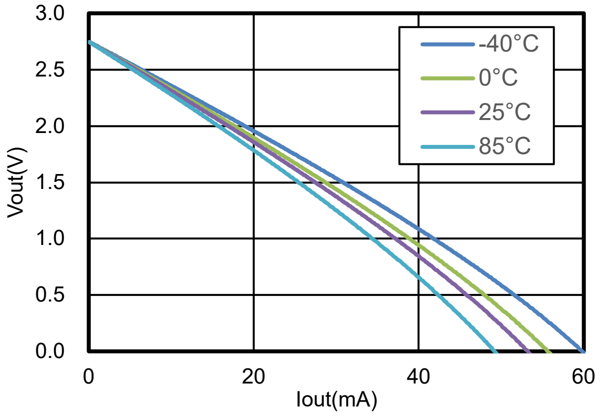


Figure 7. Output Voltage vs. Output Current. (−VS) = −2.75 V, (+VS) = 2.75 V

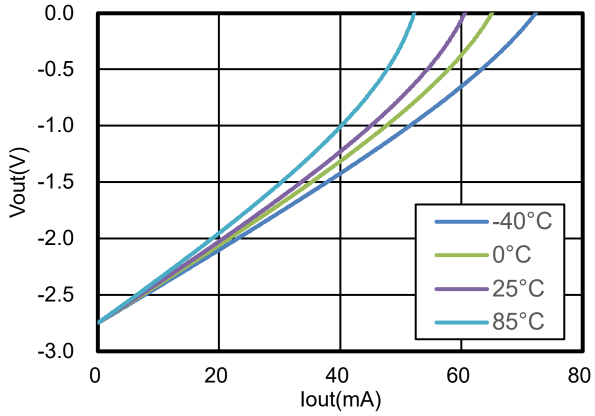


Figure 8. Output Voltage vs. Output Current, (−VS) = −2.75 V, (+VS) = 2.75 V

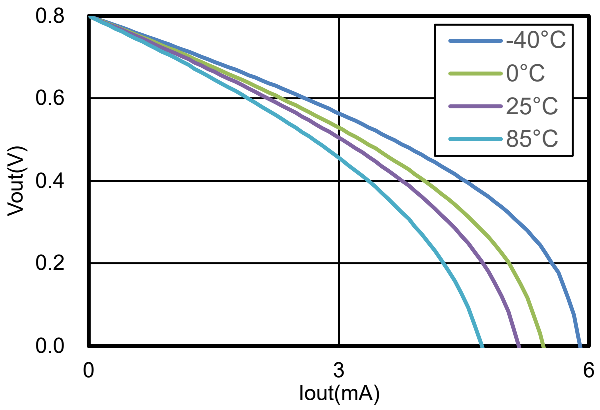


Figure 9. Output Voltage vs. Output Current, (−VS) = −0.8 V, (+VS) = 0.8 V

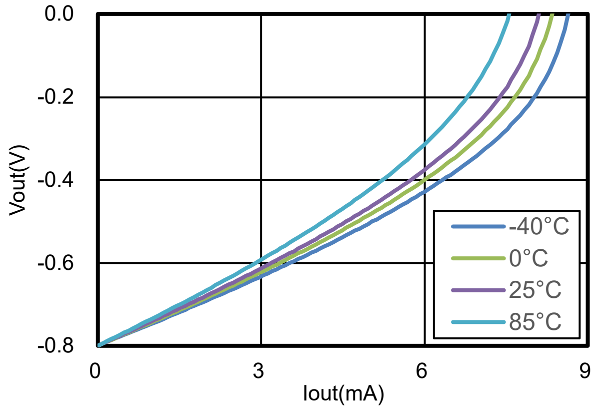


Figure 10. Output Voltage vs. Output Current, (−VS) = −0.8 V, (+VS) = 0.8 V

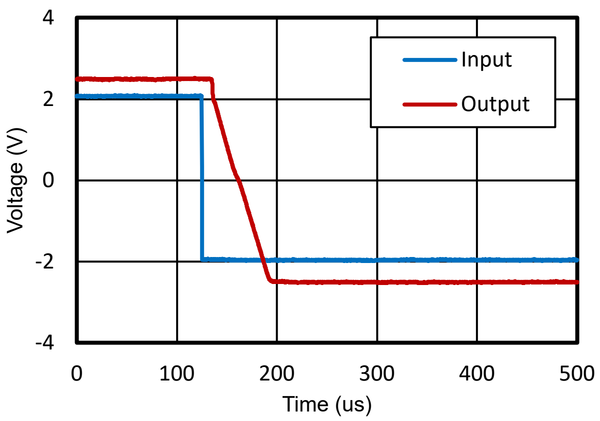


Figure 11. Overload Recovery at Negative Rail

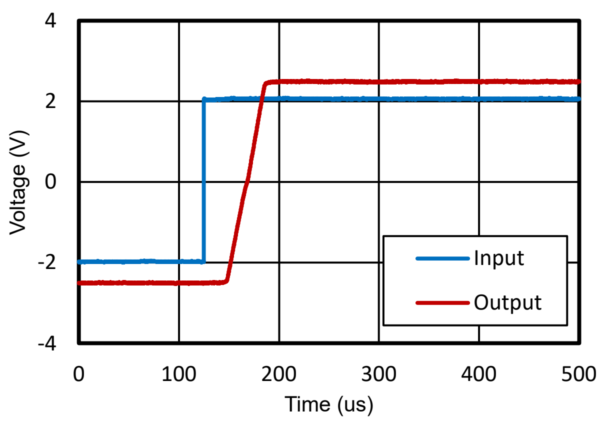


Figure 12. Overload Recovery at Positive Rail

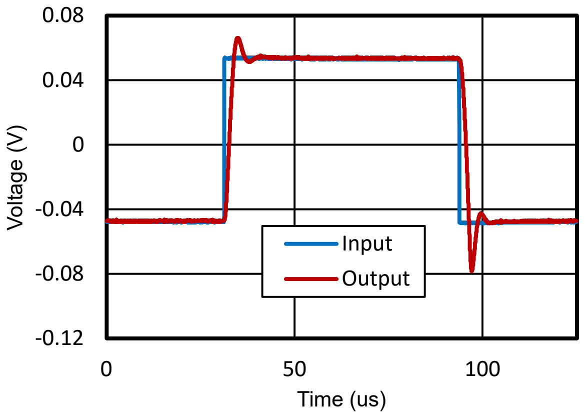


Figure 13. Small-Signal Step Response

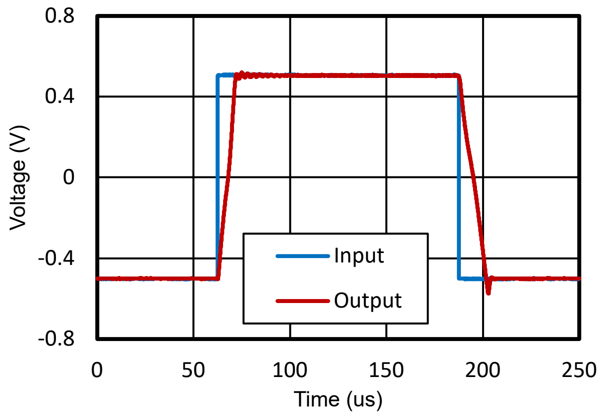


Figure 14. Large-Signal Step Response

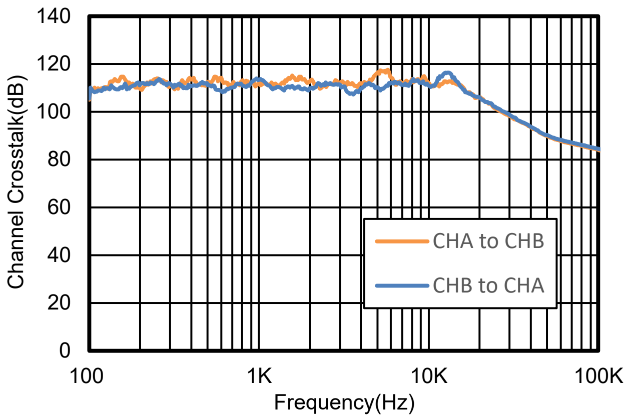


Figure 15. Crosstalk vs. Frequency

Detailed Description

Overview

The TPA611x series of op-amps can operate on a single-supply voltage (1.4 V to 5.5 V), or a split-supply voltage (±0.7 V to ±2.75 V), making them highly versatile and easy to use. The power supply pins should have local bypass ceramic capacitors (typically 0.01 μF to 0.1 μF). These amplifiers are fully specified from 1.4 V to 5.5 V and over the extended temperature range from −40°C to 85°C. Parameters that can exhibit variance with regard to operating voltage or temperature are presented in the Typical Characteristics.

Functional Block Diagram

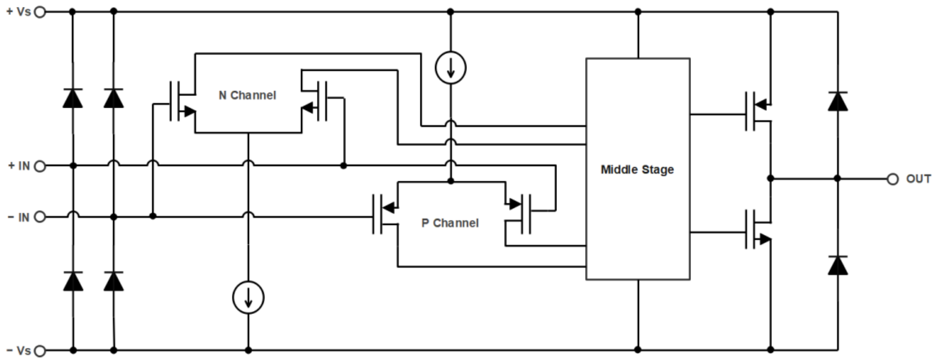


Figure 16. Functional Block Diagram

Feature Description

Operating Voltage

The devices are designed for single supply operation from 1.4 V to 5.5 V or dual supply operation from ±0.7 V to ±2.75 V. The recommended operating voltage conditions are as follows: Power supply voltage (+VS) - (-VS): 1.4 V to 5.5 V. The power supply voltage can support the following three scenarios: Single supply, Dual supplies with equal voltage values Various voltage configurations, as long as the voltage range of (+VS) - (-VS) is within 1.4 V to 5.5 V. For example, if operating with a single supply, (-VS) = 0 V, then (+VS) can support 1.4 V to 5.5 V. If using dual supplies with equal absolute values, the minimum voltage is ±0.7 V and the maximum voltage is ±2.75 V. It can even support other voltage configurations, such as (-VS) = 0 V, (+VS) = 5.5 V, or (-VS) = -1 V, (+VS) = 4.5 V, and so on.

Rail-to-Rail Input

The input common-mode voltage range of the TPA611x series extends to both positive and negative supply rails. The complementary input stage consists of a P-Channel pair and an N-Channel pair. A transition region exists in the input common-mode range. Within this transition region, PSRR, CMRR, Offset Voltage, offset drift, and THD can degrade compared to that operating outside this region.

Rail-to-Rail Output

The devices deliver rail-to-rail output swing capability with a Class-AB output stage. Different load conditions change the ability of the amplifier to swing close to the rails.

Phase Reversal Protection

Phase Reversal Protection characterizes the functionality of an Op Amp when the input common-mode voltage exceeds the negative or positive power supply rail. In most cases, the Phase Reversal happens when the Op amp is configured as a unit buffer. Once the input voltage exceeds the power supply rail, the output goes to the opposite rail. The TP611x features rail-to-rail input stage which extends the input voltage range to power supply rails. Additionally, input voltage exceeding power supply rails does not induce Phase Reversal, the output is limited at the corresponding rail.

Application and Implementation

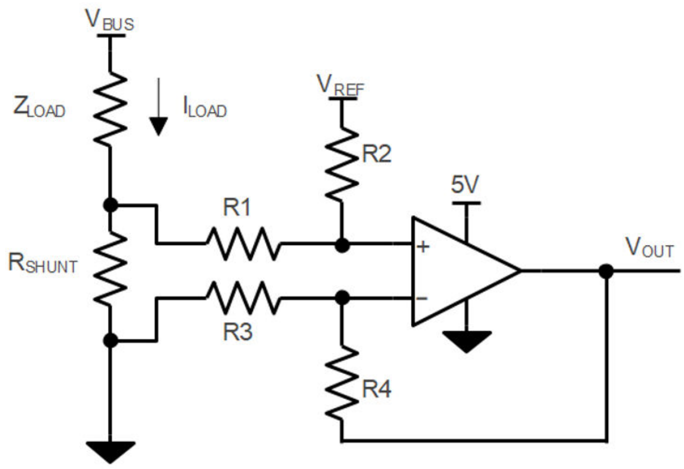
Note

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

Low-Side Current-Sensing Application

Figure 17 shows that the TPA611x series is configured in a low-side current sensing application. The low-side current sensing methods consist of placing a sense resistor between the load and the circuit ground. The voltage dropping across the resistor is amplified by different amplifier circuits with the TPA611x series. V_{REF} can be used to add bias voltage to the output voltage. Particular attention must be paid to the matching and precision of R1, R2, R3, and R4, to maximize the accuracy of the measurement.



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

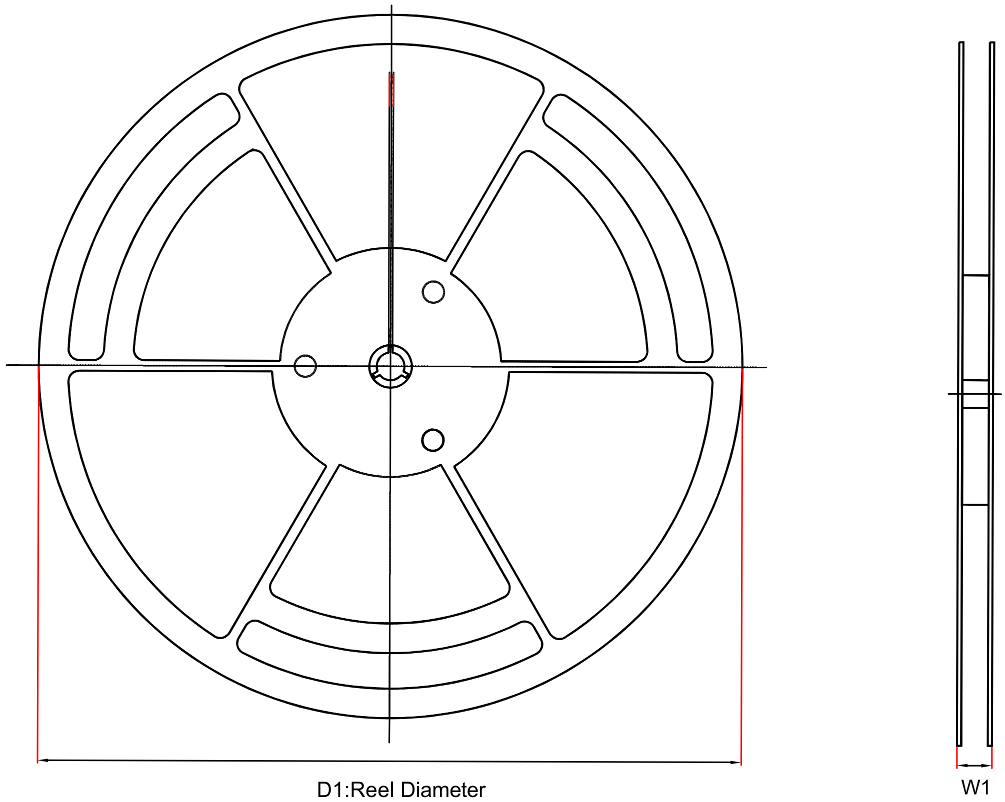
When $R3 = R1$, $R2 = R4$, $R_{SHUNT} << R1$

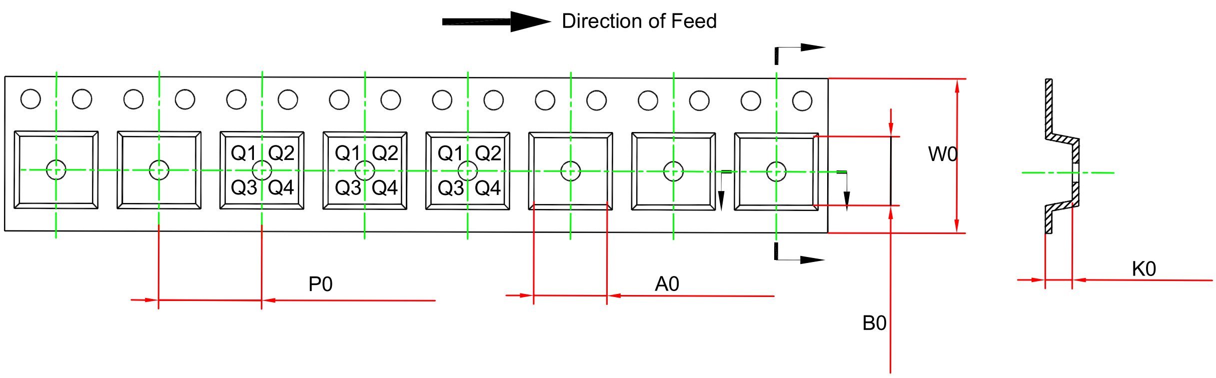
Figure 17. Dual-Supply Operation Connections

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.

Tape and Reel Information





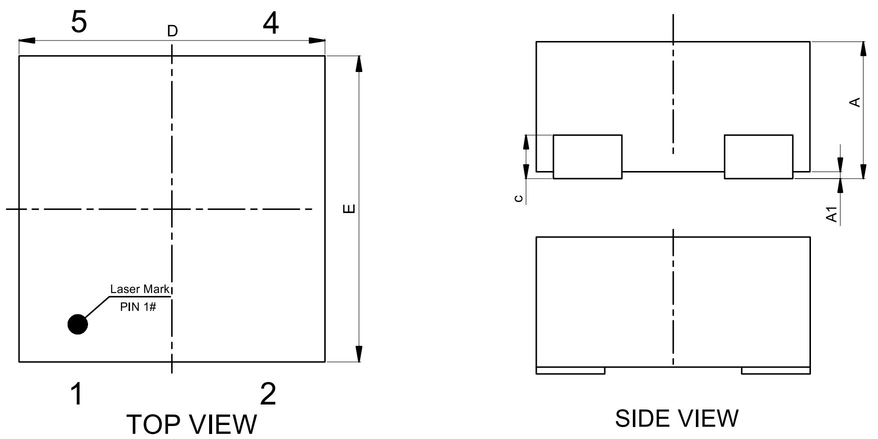
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) (1)	B0 (mm) (1)	K0 (mm) (1)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA6111-DF0R	DFN0.8X0.8-4	180	12.5	0.91	0.91	0.5	2	8	Q1
TPA6112-DF4R	DFN2X2-8	180	12.5	2.15	2.15	0.88	4	8	Q2

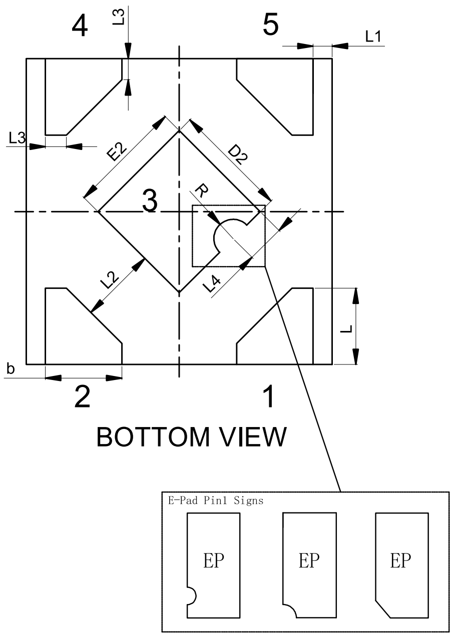
(1) The value is for reference only. Contact the 3PEAK factory for more information.

Package Outline Dimensions

DFN0.8×0.8-4

Package Outline Dimensions DF0(DFN0.8X0.8-4-A)





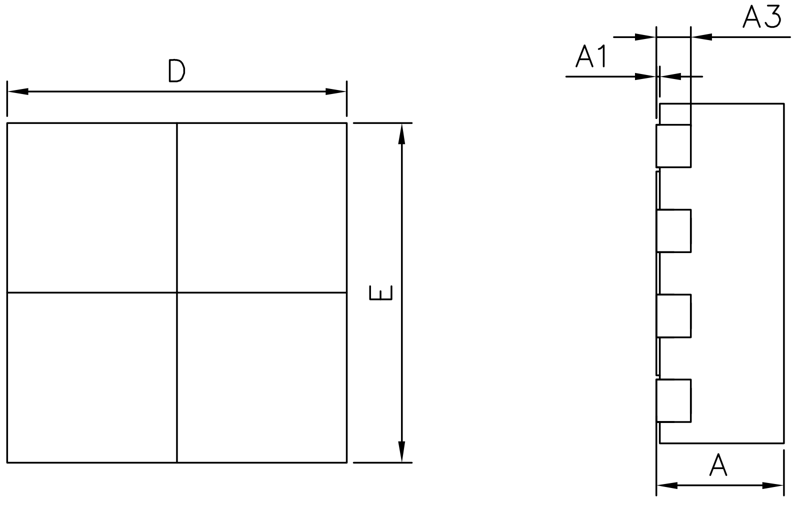
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.370	0.430	0.015	0.017
A1	0.000	0.050	0.000	0.002
b	0.150	0.250	0.006	0.010
c	0.100	0.150	0.004	0.006
D	0.750	0.850	0.030	0.033
D2	0.200	0.400	0.008	0.016
E	0.750	0.850	0.030	0.033
E2	0.200	0.400	0.008	0.016
e	0.500 BSC		0.020 BSC	
L	0.150	0.250	0.006	0.010
L1	0.050 BSC		0.002 BSC	
L2	0.200 BSC		0.008 BSC	
L3	0.055 BSC		0.002 BSC	
L4	0.100 BSC		0.004 BSC	

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.

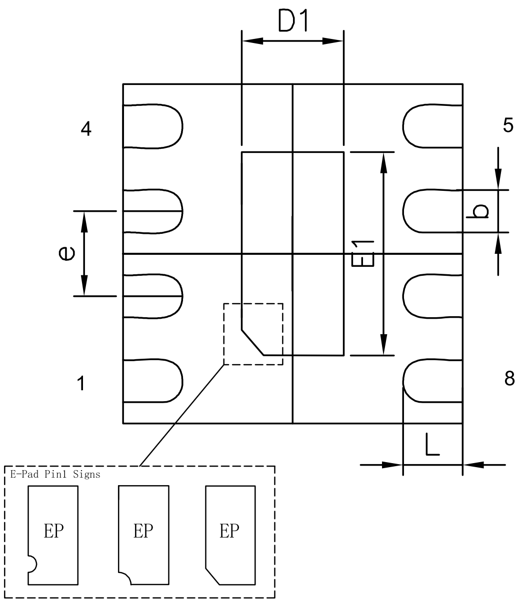
DFN2X2-8

Package Outline Dimensions DF4(DFN2X2-8-D)



Top View

Side View



Bottom View

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	0.180	0.300	0.007	0.012
A3	0.150	0.250	0.006	0.010
D	1.900	2.100	0.075	0.083
D1	0.800	1.000	0.031	0.039
E	1.900	2.100	0.075	0.083
E1	1.500	1.700	0.059	0.067
e	0.500 BSC		0.020BSC	
L	0.250	0.350	0.010	0.014

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

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPA6111-DF0R	−40 to 85°C	DFN0.8×0.8-4 (5 Pin)	1	3	Tape and Reel, 12000	Green
TPA6112-DF4R	−40 to 85°C	DFN2×2-8	611	3	Tape and Reel, 3000	Green

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

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