

OPAx354-Q1 250MHz, Rail-to-Rail I/O, CMOS Operational Amplifiers

1 Features

- Qualified for Automotive Applications
- AEC-Q100 Qualified With the Following Results:
 - Device Temperature Grade: -40°C to $+125^{\circ}\text{C}$
 - Ambient Operating Temperature Range
- Unity-Gain Bandwidth: 250MHz
- Wide Bandwidth: 100MHz GBW Product
- High Slew Rate: $150\text{V}/\mu\text{s}$
- Low Noise: $6.5\text{nV}/\sqrt{\text{Hz}}$
- Rail-to-Rail I/O
- High Output Current: $>100\text{mA}$
- Excellent Video Performance
 - Differential Gain Error: 0.02%
 - Differential Phase Error: 0.09°
 - 0.1dB Gain Flatness: 40MHz
- Low Input Bias Current: 3pA
- Quiescent Current: 5mA
- Thermal Shutdown
- Supply Range: 2.5V to 5.5V

2 Applications

- Navigation and Radio System
- Blind-Spot Detection
- Short-to-Mid Range Radar
- Video Processing
- Ultrasound
- Optical Networking, Tunable Lasers
- Photodiode Transimpedance Amplifiers
- Active Filters
- High-Speed Integrators
- Analog-to-Digital Converter (ADC) Input Buffers
- Digital-to-Analog Converter (DAC) Output Amplifiers
- Barcode Scanners
- Communications

3 Description

The design of the OPAx354-Q1 family of high-speed, voltage-feedback CMOS operational amplifiers is for video and other applications requiring wide bandwidth. These devices are unity-gain stable and can drive large output currents. Differential gain is 0.02% and differential phase is 0.09° . Quiescent current is only 5mA per channel.

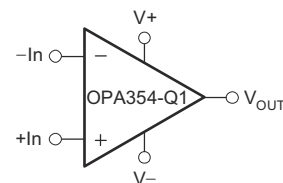
The OPAx354-Q1 family of operational amplifiers (op-amps) are optimized for operation on single or dual supplies as low as 2.5V ($\pm 1.25\text{V}$) and up to 5.5V ($\pm 2.75\text{V}$). Common-mode input range extends beyond the supplies. The output swing is within 100mV of the rails, supporting wide dynamic range.

The single-supply version (OPA354A-Q1) is available in the tiny SOT-23-5 (DBV) package. The dual-supply version (OPA2354A-Q1) is available in the miniature VSSOP-8 (DGK) package and features completely independent circuitry for lowest crosstalk and freedom from interaction. The quad-supply version (OPA4354-Q1) is available in the TSSOP-14 (PW) package. The device specifications are for operation over the automotive temperature range of -40°C to $+125^{\circ}\text{C}$.

Package Information

PART NUMBER	PACKAGE ⁽¹⁾	PACKAGE SIZE ⁽²⁾
OPA354A-Q1	DBV (SOT-23 5)	2.90mm × 1.60mm
OPA2354A-Q1	DGK (VSSOP 8)	3.00mm × 3.00mm
OPA4354-Q1	PW (TSSOP 14)	5.00mm × 4.40mm

- (1) For all available packages, see the orderable addendum at the end of the data sheet.
- (2) The package size (length × width) is a nominal value and includes pins, where applicable.



Simplified Schematic



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4 Pin Configuration and Functions

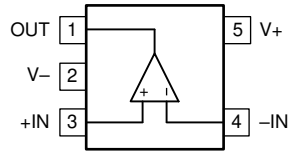


Figure 4-1. OPA354A-Q1 DBV Package 5-Pin SOT-23 Top View

Table 4-1. Pin Functions: OPA354A-Q1

PIN		I/O	DESCRIPTION
NAME	NO.		
+IN	3	I	Noninverting input
-IN	4	I	Inverting input
OUT	1	O	Output
V+	5	—	Positive (highest) supply
V-	2	—	Negative (lowest) supply

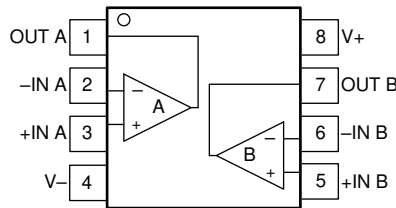


Figure 4-2. OPA2354A-Q1 DGK Package 8-Pin VSSOP Top View

Table 4-2. Pin Functions: OPA2354A-Q1

PIN		I/O	DESCRIPTION
NAME	NO.		
+IN A	3	I	Noninverting input, channel A
+IN B	5	I	Noninverting input, channel B
-IN A	2	I	Inverting input, channel A
-IN B	6	I	Inverting input, channel B
OUT A	1	O	Output, channel A
OUT B	7	O	Output, channel B
V+	8	—	Positive (highest) supply
V-	4	—	Negative (lowest) supply

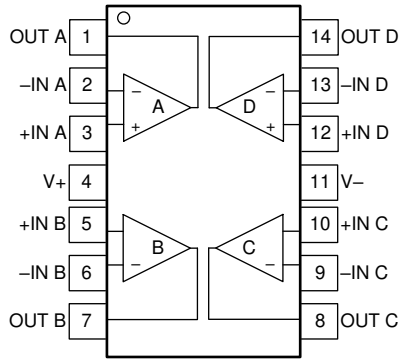


Figure 4-3. OPA4354-Q1 PW Package 14-Pin TSSOP Top View

Table 4-3. Pin Functions: OPA4354-Q1

PIN		I/O	DESCRIPTION
NAME	NO.		
+IN A	3	I	Noninverting input, channel A
+IN B	5	I	Noninverting input, channel B
+IN C	10	I	Noninverting input, channel C
+IN D	12	I	Noninverting input, channel D
-IN A	2	I	Inverting input, channel A
-IN B	6	I	Inverting input, channel B
-IN C	9	I	Inverting input, channel C
-IN D	13	I	Inverting input, channel D
OUT A	1	O	Output, channel A
OUT B	7	O	Output, channel B
OUT C	1	O	Output, channel C
OUT D	7	O	Output, channel D
V+	5	—	Positive (highest) supply
V-	2	—	Negative (lowest) supply

5 Specifications

5.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted)⁽¹⁾

		MIN	MAX	UNIT
V _S	Supply voltage, V _S = (V+) – (V–)		7.5	V
V _I	Signal input terminals	(V–) – 0.5	(V+) + 0.5	V
I _{SC}	Output short-circuit ⁽²⁾	Continuous		
T _A	Operating temperature	–55	125	°C
T _J	Junction temperature		150	°C
T _{stg}	Storage temperature	–65	150	°C

- (1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
- (2) Short-circuit to ground, one amplifier per package.

5.2 ESD Ratings

			VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human body model (HBM), per AEC Q100-002 ⁽¹⁾ Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽²⁾	±2000	V
		For OPA354A-Q1 and OPA2354A-Q1, Charged device model (CDM), per AEC Q100-011 Charged device model (CDM), per ANSI/ESDA/JEDEC JS-002 ⁽³⁾	±1000	
V _(ESD)	Electrostatic discharge	For OPA4354-Q1, Charged device model (CDM), per AEC Q100-011	±250	V

- (1) AEC Q100-002 indicates that HBM stressing must be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.
- (2) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
- (3) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

5.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V _S	Supply voltage, V _S = (V+) – (V–)	2.5		5.5	V
T _A	Specified temperature	–40	25	125	°C

5.4 Thermal Information

THERMAL METRIC ⁽¹⁾		OPA354A-Q1	OPA2354A-Q1	OPA4354-Q1	UNIT
		DBV (SOT-23)	DGK (VSSOP)	PW (TSSOP)	
		5 PINS	8 PINS	14 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	216.3	175.9	92.6	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	115.0	67.8	27.5	°C/W
R _{θJB}	Junction-to-board thermal resistance	83.2	97.1	33.6	°C/W
ψ _{JT}	Junction-to-top characterization parameter	50.3	9.3	1.9	°C/W
ψ _{JB}	Junction-to-board characterization parameter	82.7	95.5	33.1	°C/W
R _{θJC(bot)}	Junction-to-case (bottom) thermal resistance	N/A	N/A	N/A	°C/W

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

5.5 Electrical Characteristics

at $T_A = 25^\circ\text{C}$, $R_F = 0\Omega$, $R_L = 1\text{k}\Omega$, and connected to $V_S/2$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
OFFSET VOLTAGE						
V _{OS}	Input offset voltage	V _S = 5V, T _A = 25°C		±2	±8	mV
		V _S = 5V, T _A = −40°C to +125°C			±10	mV
dV _{OS} /dT	Input offset voltage drift	V _S = 5V, T _A = −40°C to +125°C		±4		μV/°C
PSRR	Power-supply rejection ratio	V _S = 2.7V to 5.5V, V _{CM} = (V _S / 2) − 0.55V		±200	±800	μV/V
		V _S = 2.7V to 5.5V, V _{CM} = (V _S / 2) − 0.55V, T _A = −40°C to +125°C			±900	
INPUT BIAS CURRENT						
I _B	Input bias current ⁽²⁾			3	±50	pA
I _{OS}	Input offset current ⁽²⁾			±1	±50	
NOISE						
e _n	Input voltage noise density	f = 1MHz		6.5		nV/√Hz
i _n	Input current noise density	f = 1MHz, for OPA2354A-Q1, OPA4354-Q1		50		fA/√Hz
		f = 1MHz, for OPA354A-Q1		300		
INPUT VOLTAGE RANGE						
V _{CM}	Common-mode voltage		(V−) − 0.1		(V+) + 0.1	V
CMRR	Common-mode rejection ratio	V _S = 5.5V, −0.1V < V _{CM} < 3.5V, T _A = 25°C	66	80		dB
		V _S = 5.5V, −0.1V < V _{CM} < 3.5V, T _A = −40°C to +125°C	64			
		V _S = 5.5V, −0.1V < V _{CM} < 5.6V, T _A = 25°C	56	68		
		V _S = 5.5V, −0.1V < V _{CM} < 5.6V, T _A = −40°C to +125°C	55			
INPUT IMPEDANCE						
C _{IN}	Differential			10 ¹³ 2		Ω pF
	Common-mode			10 ¹³ 2		
OPEN-LOOP GAIN						
A _{OL}	Open-loop gain	V _S = 5.5V, 0.3V < V _O < 4.7V, T _A = 25°C	94	110		dB
		V _S = 5.5V, 0.4V < V _O < 4.6V, T _A = −40 to +125°C	90			
FREQUENCY RESPONSE						
f _{−3dB}	Gain-bandwidth product	G = +1, V _O = 100mV _{PP} , R _F = 25Ω		250		MHz
		G = +2, V _O = 100mV _{PP}		90		
GBW	Gain-bandwidth product	G = +10		100		MHz
f _{0.1dB}	Bandwidth for 0.1dB gain flatness	G = +2, V _O = 100mV _{PP}		40		MHz
SR	Slew rate	V _S = 5V, G = +1, 4V step		150		V/μs
		V _S = 5V, G = +1, 2V step		130		
		V _S = 3V, G = +1, 2V step		110		
	Rise-and-fall time	G = +1, V _O = 200mV _{PP} , 10% to 90%, for OPA2354A-Q1, OPA4354-Q1		2		ns
G = +1, V _O = 200mV _{PP} , 10% to 90%, for OPA354A-Q1			3			
G = +1, V _O = 2V _{PP} , 10% to 90%			11			
t _S	Settling time	0.1%, V _S = 5V, G = +1, 2V output step		30		ns
		0.01%, V _S = 5V, G = +1, 2V output step		60		

5.5 Electrical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $R_F = 0\Omega$, $R_L = 1\text{k}\Omega$, and connected to $V_S/2$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
	Overload recovery time	$V_{IN} \times G = V_S$		5		ns
HD2	Second-order harmonic distortion	$G = +1$, $f = 1\text{MHz}$, $V_O = 2V_{PP}$, $R_L = 200\Omega$, $V_{CM} = (V_-) + 1.5\text{V}$		-75		dBc
HD3	Third-order harmonic distortion	$G = +1$, $f = 1\text{MHz}$, $V_O = 2V_{PP}$, $R_L = 200\Omega$, $V_{CM} = (V_-) + 1.5\text{V}$		-83		dBc
	Differential gain error	NTSC, $R_L = 150\Omega$		0.02%		
	Differential phase error	NTSC, $R_L = 150\Omega$		0.09		°
	Channel-to-channel crosstalk	OPA2354 A-Q1, $f = 5\text{MHz}$		-100		dB
	Channel-to-channel crosstalk	OPA4354-Q1, $f = 5\text{MHz}$		-84		dB
OUTPUT						
	Output voltage swing from supply rails	$V_S = 5\text{V}$, $A_{OL} > 94\text{dB}$		0.1	0.3	V
		$V_S = 5\text{V}$, $R_L = 1\text{k}\Omega$, $A_{OL} > 90\text{dB}$, $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			0.4	
I_O	Output current, single, dual, quad ⁽¹⁾ ⁽²⁾	$V_S = 5\text{V}$	100			mA
		$V_S = 3\text{V}$		50		
	Closed-loop output impedance	$f < 100\text{kHz}$		0.05		Ω
R_O	Open-loop output resistance	For OPA2354A-Q1, OPA4354-Q1		35		Ω
		For OPA354A-Q1		39		Ω
POWER SUPPLY						
I_Q	Quiescent current (per amplifier)	$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$ (enabled), $I_O = 0\text{A}$, for OPA2354A-Q1, OPA4354-Q1		4.9	6	mA
		$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$ (enabled), $I_O = 0\text{A}$, for OPA354A-Q1		5	6.3	
		$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$, for OPA2354A- Q1, OPA4354-Q1			7.5	
		$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$, for OPA354A-Q1			7.7	
THERMAL SHUTDOWN: JUNCTION TEMPERATURE						
	Shutdown			160		$^\circ\text{C}$
	Reset from shutdown			140		$^\circ\text{C}$

(1) See the typical characteristic curves for output voltage swing vs output current.

(2) Specified by design.

5.6 Typical Characteristics

at $T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $G = +1$, $R_F = 0\Omega$, $R_L = 1\text{k}\Omega$, and connected to $V_S / 2$, unless otherwise noted.

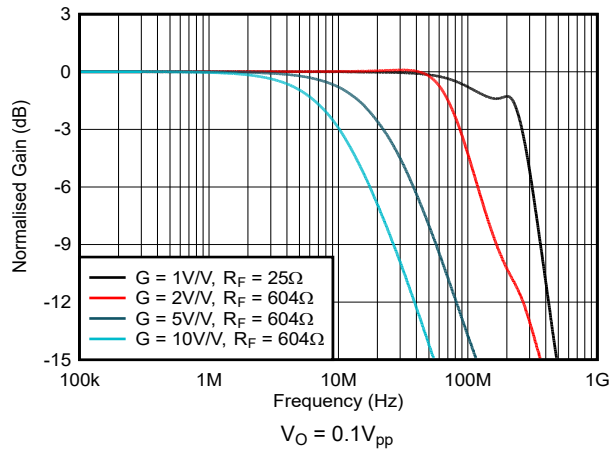


Figure 5-1. Non-inverting Small- Signal Frequency Response

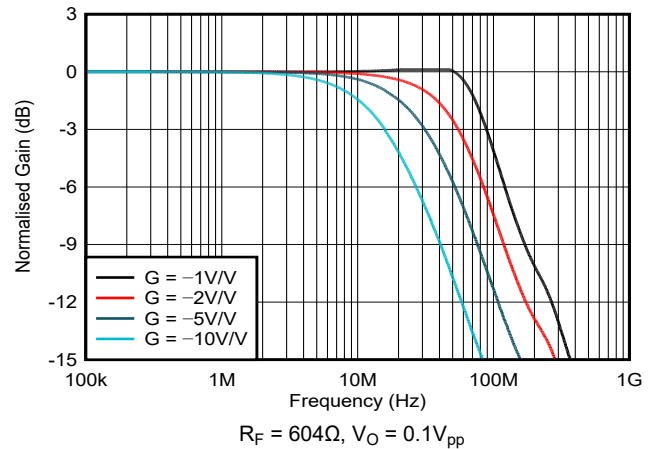


Figure 5-2. Inverting Small- Signal Frequency Response

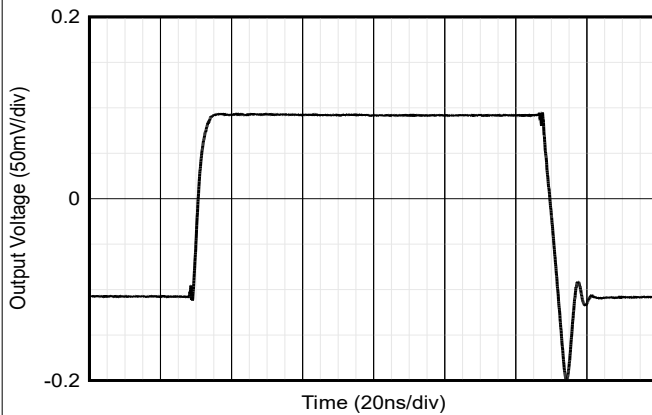


Figure 5-3. Non-inverting Small- Signal Step Response

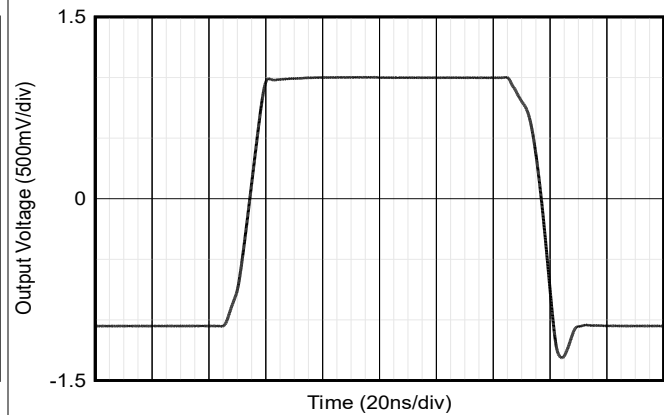


Figure 5-4. Non-inverting Large- Signal Step Response

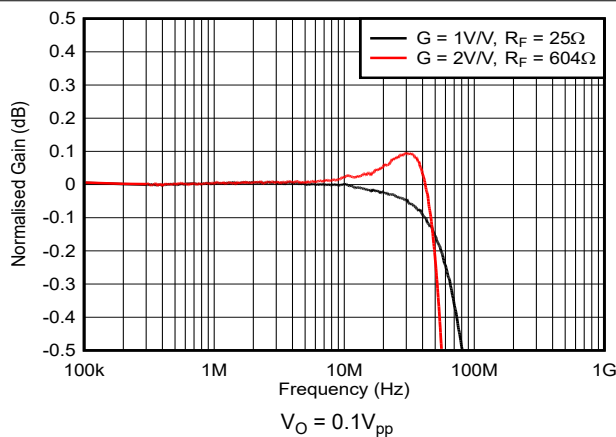


Figure 5-5. 0.1dB Gain Flatness

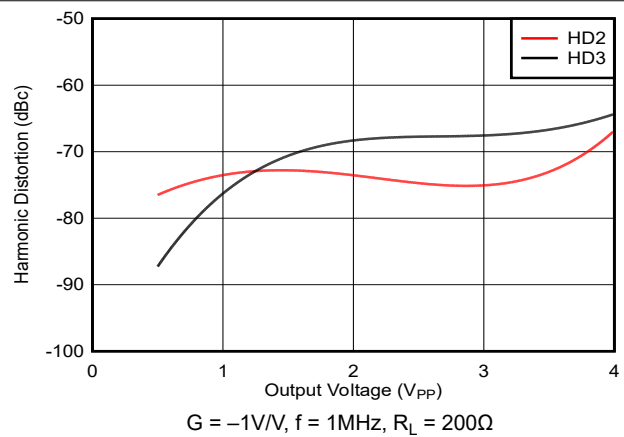
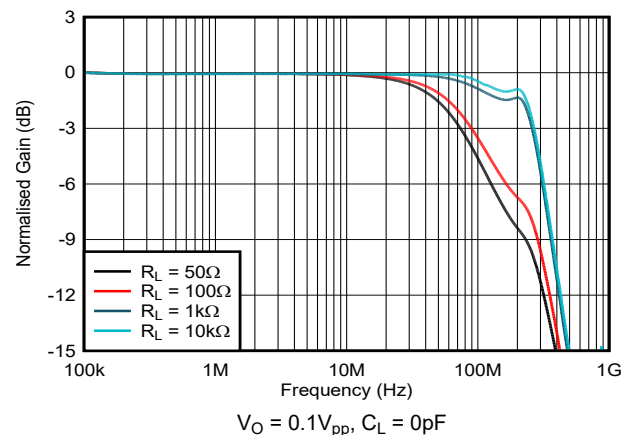
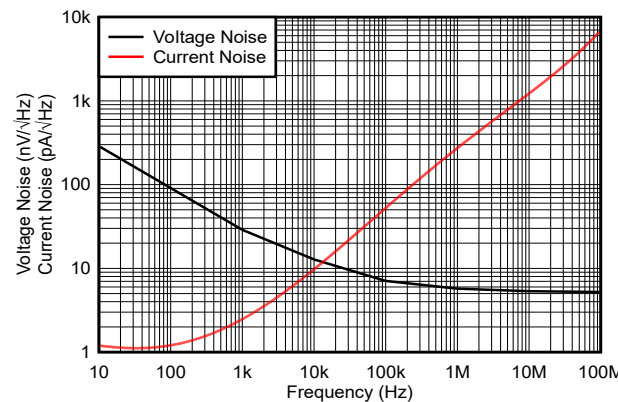
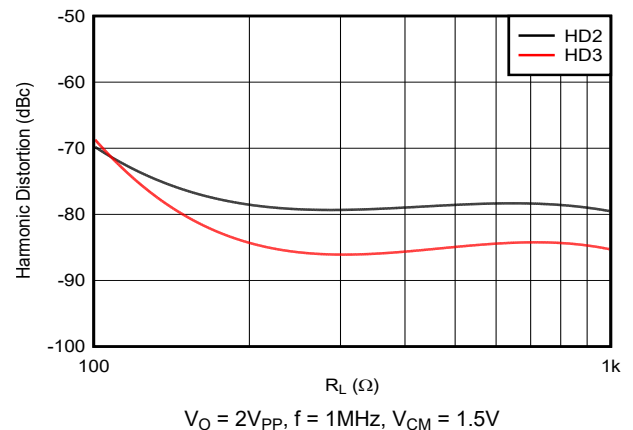
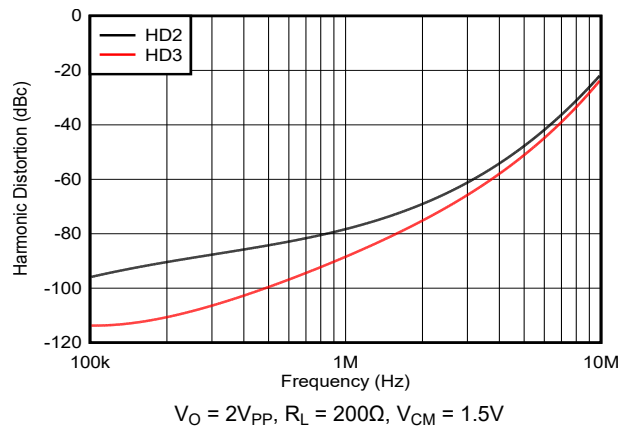
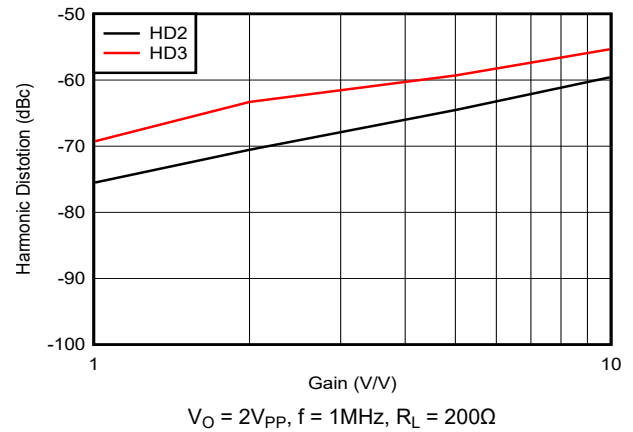
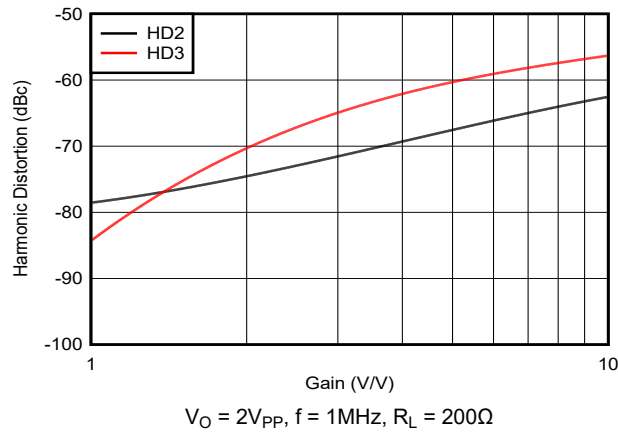


Figure 5-6. Harmonic Distortion vs Output Voltage

5.6 Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $G = +1$, $R_F = 0\Omega$, $R_L = 1\text{k}\Omega$, and connected to $V_S / 2$, unless otherwise noted.



5.6 Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $G = +1$, $R_F = 0\Omega$, $R_L = 1\text{k}\Omega$, and connected to $V_S / 2$, unless otherwise noted.

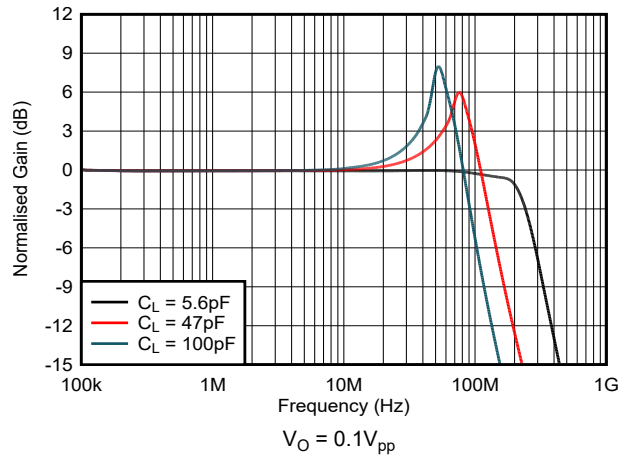


Figure 5-13. Frequency Response for Various C_L Values

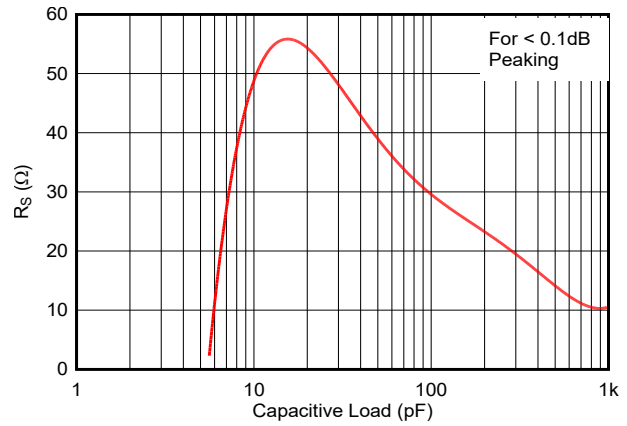


Figure 5-14. Recommended R_S vs Capacitive Load

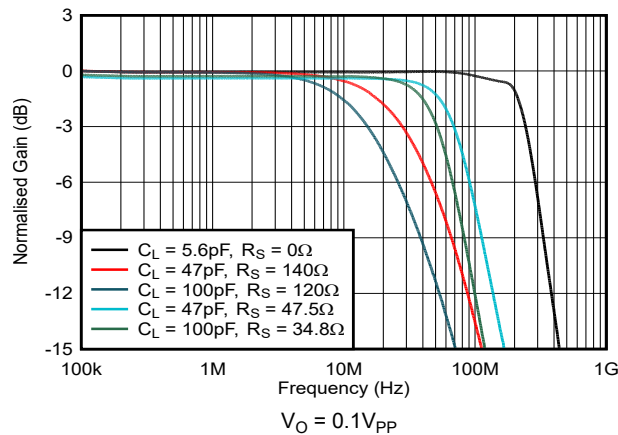


Figure 5-15. Frequency Response vs Capacitive Load

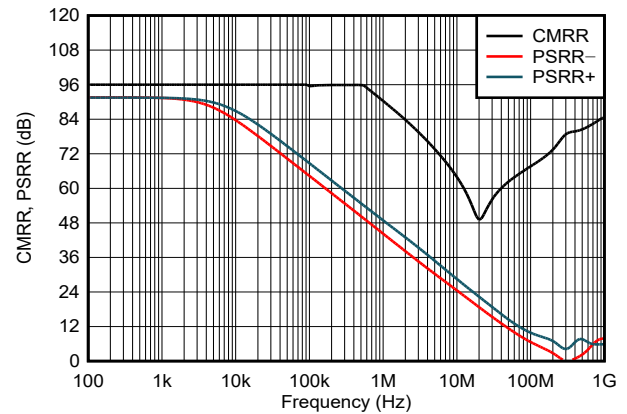


Figure 5-16. Common-Mode Rejection Ratio and Power-Supply Rejection Ratio vs Frequency

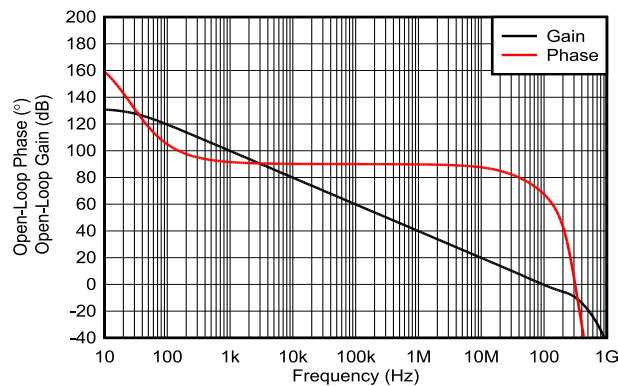


Figure 5-17. Open-Loop Gain and Phase

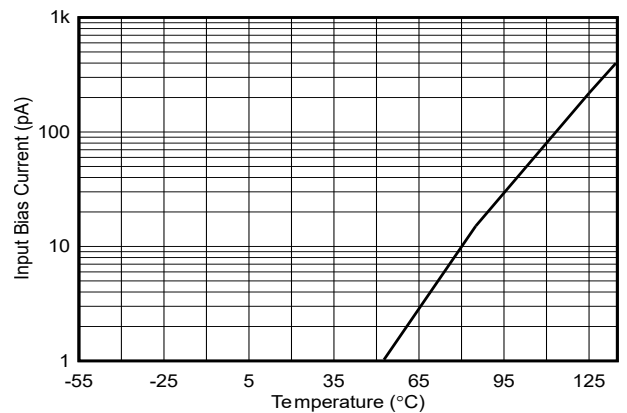


Figure 5-18. Input Bias Current vs Temperature

5.6 Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $G = +1$, $R_F = 0\Omega$, $R_L = 1\text{k}\Omega$, and connected to $V_S / 2$, unless otherwise noted.

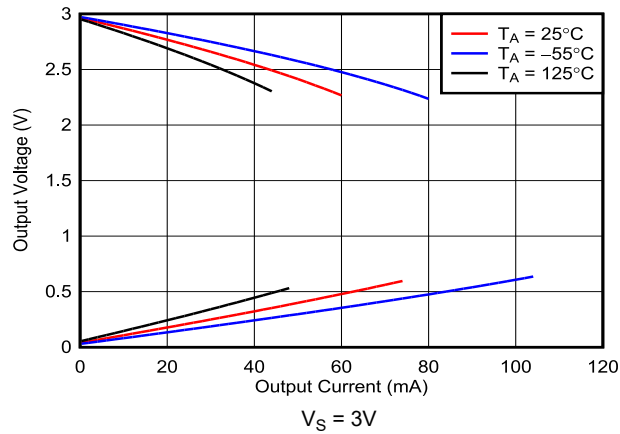


Figure 5-19. Output Voltage Swing vs Output Current

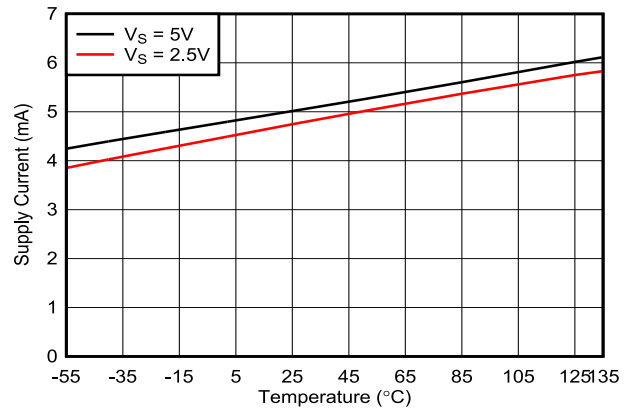


Figure 5-20. Supply Current vs Temperature

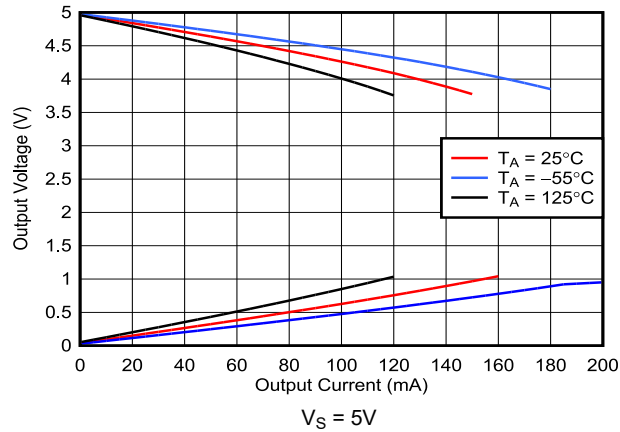


Figure 5-21. Output Voltage Swing vs Output Current

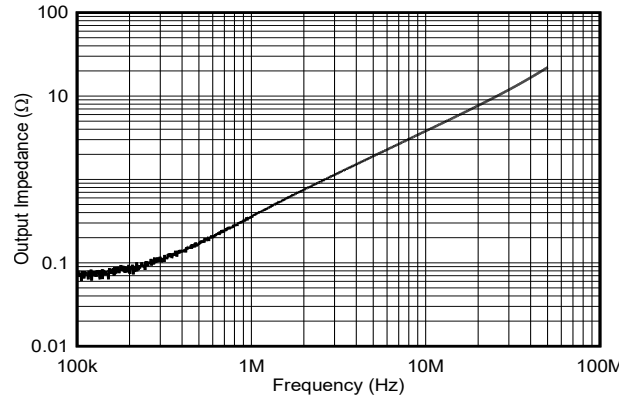


Figure 5-22. Closed-Loop Output Impedance vs Frequency

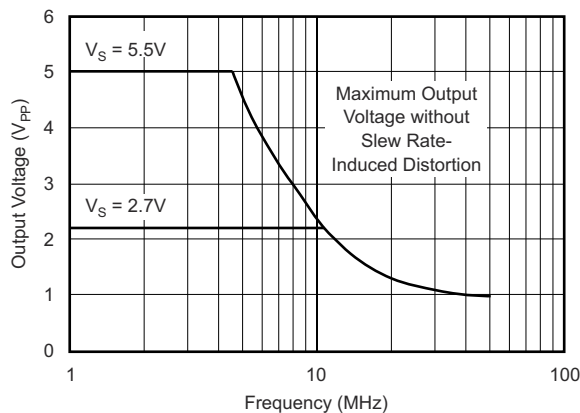


Figure 5-23. Maximum Output Voltage vs Frequency

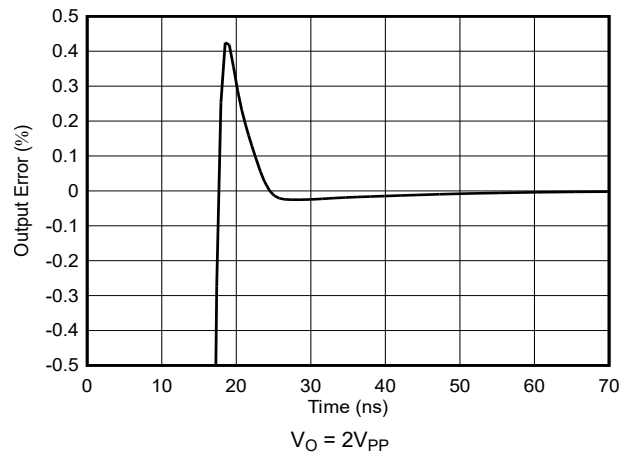


Figure 5-24. Output Settling Time to 0.1%

5.6 Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $G = +1$, $R_F = 0\Omega$, $R_L = 1\text{k}\Omega$, and connected to $V_S / 2$, unless otherwise noted.

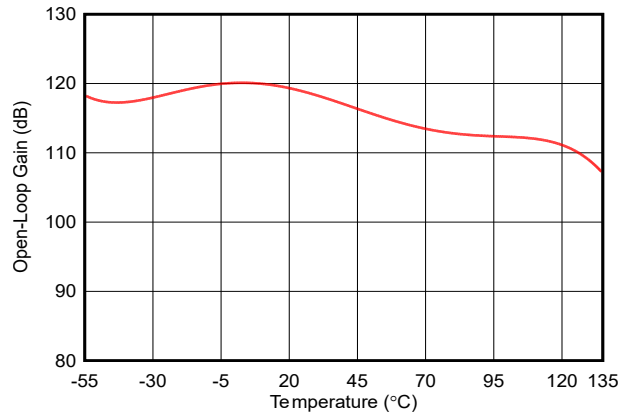


Figure 5-25. Open- Loop Gain vs Temperature

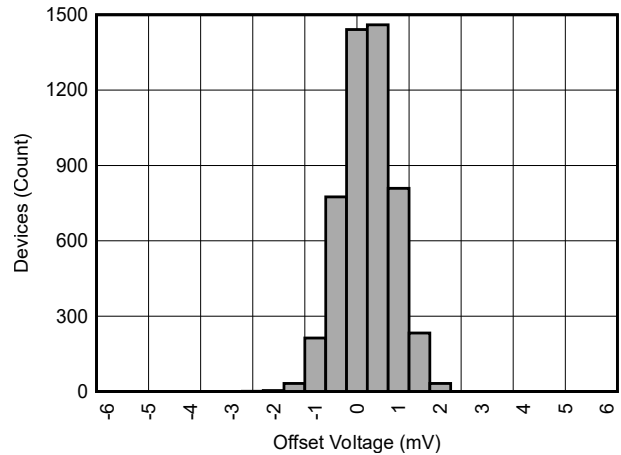


Figure 5-26. Offset Voltage Production Distribution

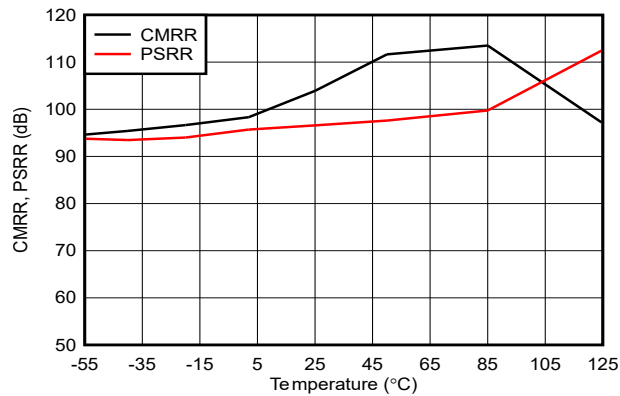


Figure 5-27. Common-mode Rejection Ratio and Power-supply Rejection Ratio vs Temperature

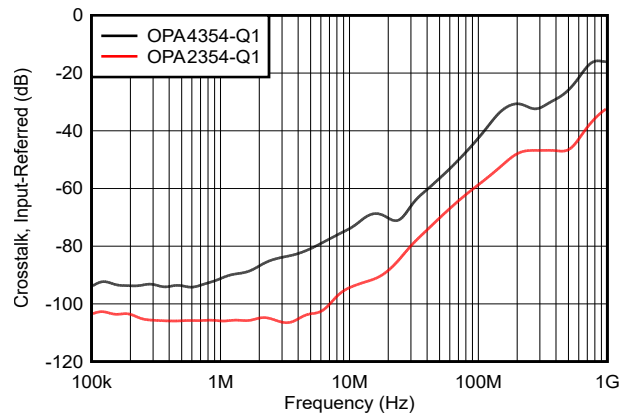


Figure 5-28. Channel-to-channel crosstalk

6 Detailed Description

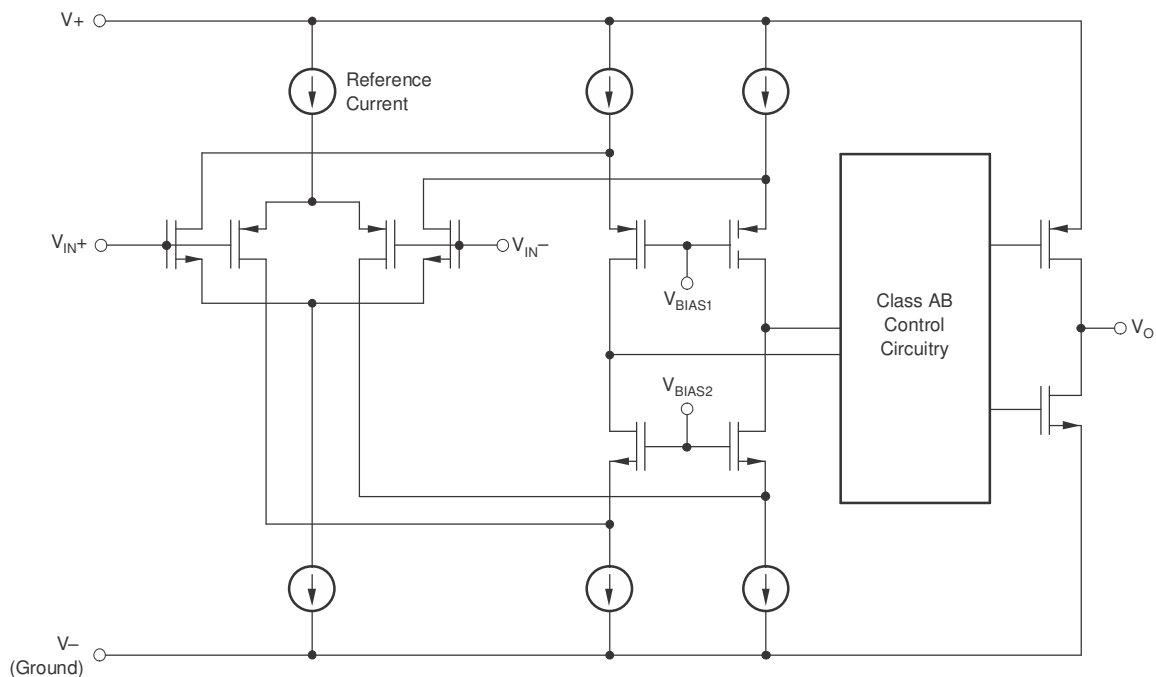
6.1 Overview

The OPAx354-Q1 operational amplifiers are high-speed, 150V/ μ s, amplifiers making them excellent choices for transimpedance applications. The devices are unity-gain stable and can operate on a single-supply voltage (2.5V to 5.5V), or a split-supply voltage (± 1.25 V to ± 2.75 V), making them highly versatile and easy to use. The OPAx354A-Q1 amplifiers are specified from 2.5V to 5.5V and over the automotive temperature range of -40°C to $+125^{\circ}\text{C}$.

Table 6-1. OPAx354-Q1 Related Products

FEATURES	PRODUCT
Shutdown Version of OPA354 Family	OPAx357
200MHz GBW, Rail-to-Rail Output, CMOS, Shutdown	OPAx355
200MHz GBW, Rail-to-Rail Output, CMOS	OPAx356
38MHz GBW, Rail-to-Rail Input/Output, CMOS	OPAx350/3
75MHz BW, $G = 2$, Rail-to-Rail Output	OPAx631
150MHz BW, $G = 2$, Rail-to-Rail Output	OPAx634
100MHz BW, Differential Input/Output, 3.3V Supply	THS412x

6.2 Functional Block Diagram



6.3 Feature Description

6.3.1 Operating Voltage

The specifications of the OPAx354-Q1 family of devices apply over a power-supply range of 2.5V to 5.5V (± 1.25 V to ± 2.75 V). Supply voltages higher than 7.5V (absolute maximum) can permanently damage the amplifier.

[Section 5.6](#) of this data sheet shows the parameters that vary over supply voltage or temperature.

6.3.2 Rail-to-Rail Input

The specified input common-mode voltage range of the OPAx354-Q1 family of devices extends 100mV beyond the supply rails. A complementary input stage (an N-channel input differential pair in parallel with a P-channel

differential pair) achieves this extension. The N-channel pair is active for input voltages close to the positive rail, typically $(V+) - 1.2V$ to 100mV above the positive supply, while the P-channel pair is on for inputs from 100mV below the negative supply to approximately $(V+) - 1.2V$. A small transition region exists, typically $(V+) - 1.5V$ to $(V+) - 0.9V$, in which both pairs are on. This 600mV transition region can vary $\pm 500mV$ with process variation. As a result, the transition region (both input stages on) range from $(V+) - 2V$ to $(V+) - 1.5V$ on the low end, up to $(V+) - 0.9V$ to $(V+) - 0.4V$ on the high end.

A double-folded cascode adds the signal from the two input pairs and presents a differential signal to the class-AB output stage.

6.3.3 Rail-to-Rail Output

The device uses a class-AB output stage with common-source transistors to achieve rail-to-rail output. For high-impedance loads ($> 200\Omega$), the output voltage swing is typically 100mV from the supply rails. With 10Ω loads, a user can achieve a useful output swing while maintaining high open-loop gain; see [Figure 5-19 \(Output Voltage Swing vs Output Current\)](#).

6.3.4 Output Drive

The OPAx354-Q1 output stage supplies a continuous output current of $\pm 100mA$ and still provide approximately 2.7V output swing on a 5V supply, as shown in [Figure 6-1](#).

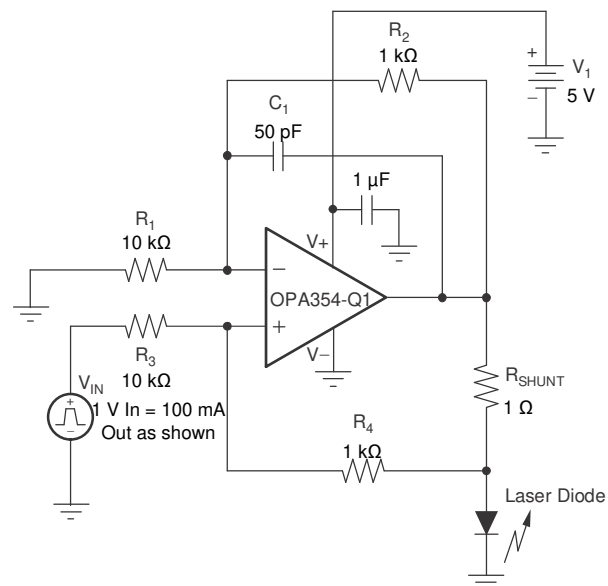


Figure 6-1. Laser Diode Driver

For maximum reliability, TI does not recommend running a continuous DC current greater than $\pm 100mA$; see [Figure 5-19 \(Output Voltage Swing vs Output Current\)](#). Operate the OPAx354-Q1 family of devices in parallel to supply continuous output currents greater than $\pm 100mA$, as shown in [Figure 6-2](#).

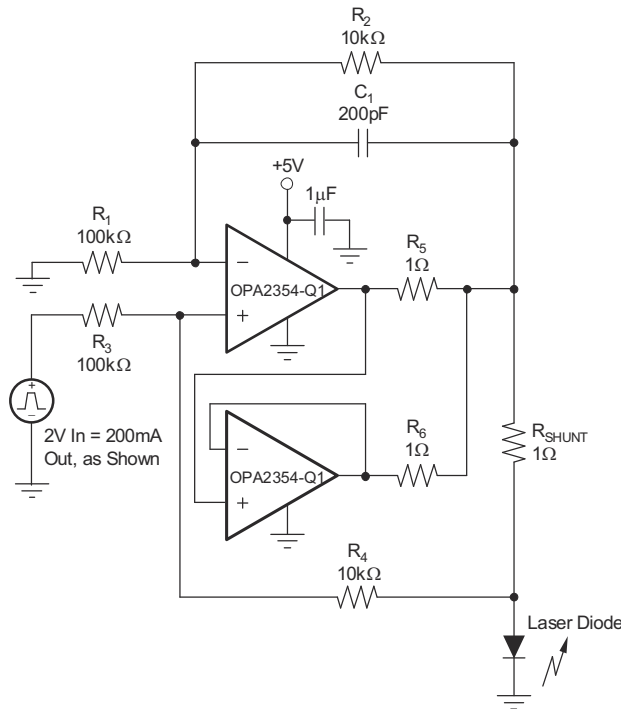


Figure 6-2. Parallel Operation

The OPAx354-Q1 family of devices provides peak currents up to 200mA, which correspond to the typical short-circuit current. Therefore, an on-chip thermal shutdown circuit protects the OPAx354-Q1 family of devices from dangerously high junction temperatures. At 160°C, the protection circuit shuts down the amplifier. Normal operation resumes when the junction temperature cools below 140°C.

6.3.5 Video

The OPAx354-Q1 output stage is capable of driving standard back-terminated 75Ω video cables (see [Figure 6-3](#)). A back-terminated transmission line does not exhibit a capacitive load to the driver. A properly back-terminated 75Ω cable does not appear as capacitance; the cable presents a 150Ω resistive load to the OPAx354-Q1 output.

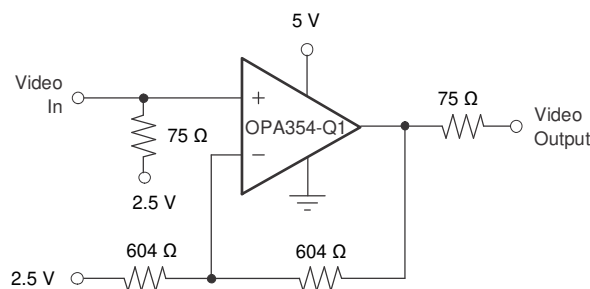
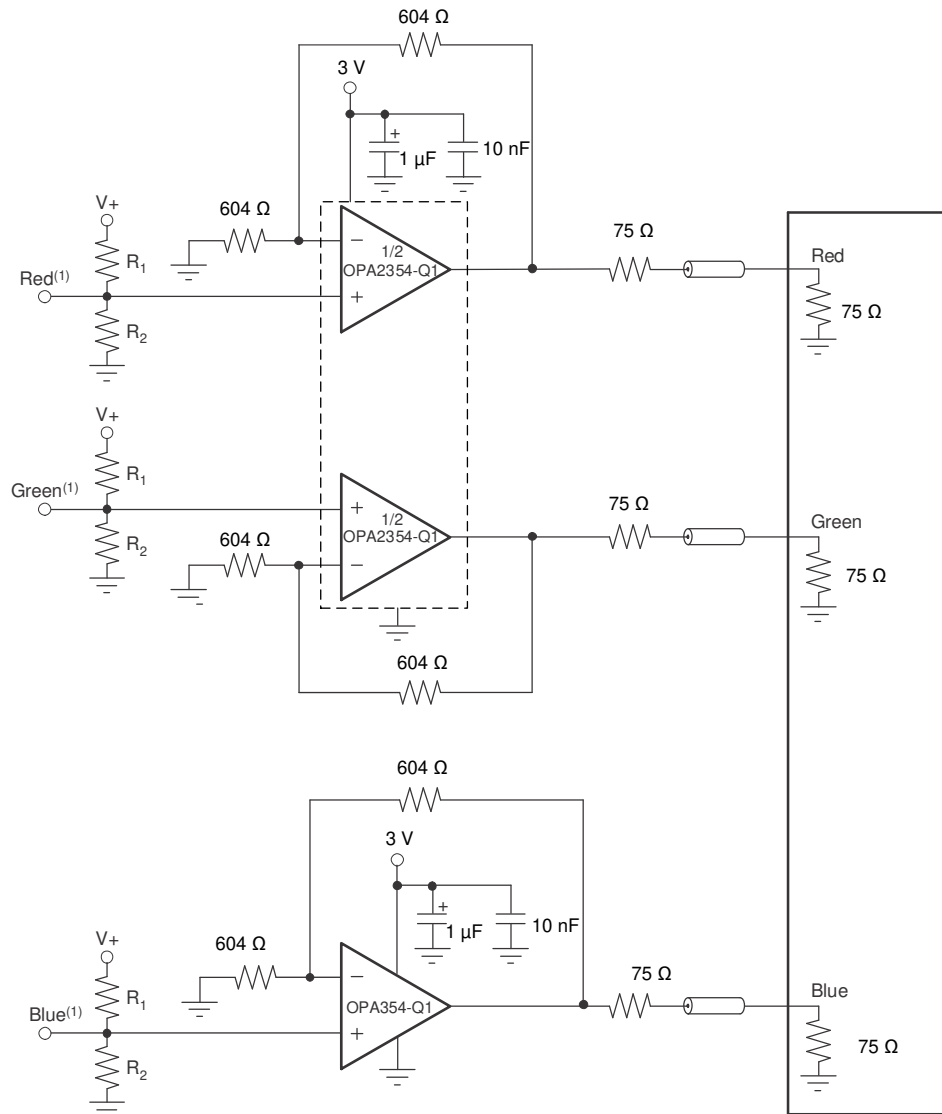


Figure 6-3. Single-Supply Video Line Driver

This series of amplifiers can be used as an amplifier for RGB graphic signals, which have a voltage of zero at the video black level by offsetting and AC-coupling the signal (see [Figure 6-4](#)).



A. Source video signal offset 300mV above ground to accommodate op amp swing to ground capability.

Figure 6-4. RGB Cable Driver

6.3.6 Driving Analog-to-Digital Converters

The OPAx354-Q1 family of op-amps offers a 60ns settling time to 0.01%, which makes the devices a viable option for driving high- and medium-speed sampling ADCs and reference circuits. The OPAx354-Q1 family of devices provides an effective means of buffering the input capacitance and resulting charge injection of the ADC while providing signal gain. The OPAx354-Q1 family of devices is designed for applications requiring high DC accuracy.

Figure 6-5 shows the OPAx354-Q1 family of devices driving an ADC. With the OPAx354-Q1 family of devices in an inverting configuration, using a capacitor across the feedback resistor can filter high-frequency noise in the signal.

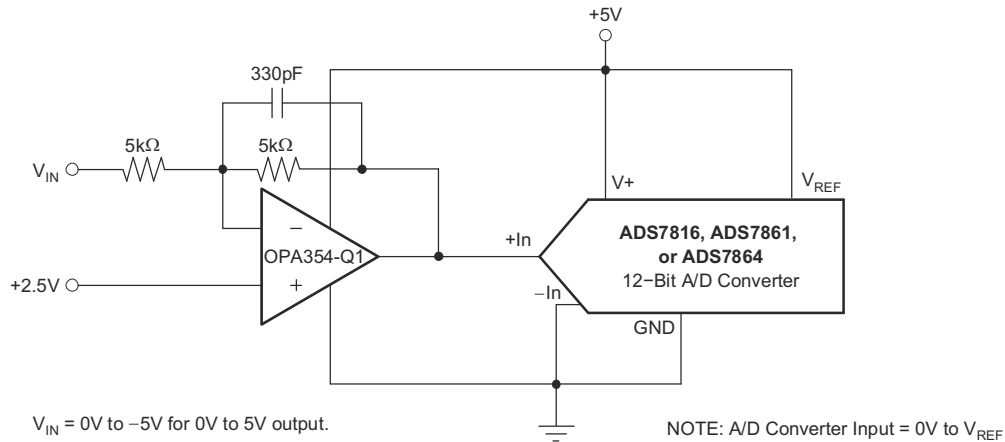


Figure 6-5. OPA354A-Q1 Inverting Configuration Driving the ADS7816

6.3.7 Capacitive Load and Stability

The OPAx354-Q1 family op amps can drive a wide range of capacitive loads. However, all op-amps under certain conditions can become unstable. Op amp configuration, gain, and load value are a few of the factors to consider when determining stability. An op amp in unity-gain configuration is most susceptible to the effects of capacitive loading. The capacitive load reacts with the output resistance of the op amp, along with any additional load resistance, to create a pole in the small-signal response that degrades the phase margin. For details, see [Figure 5-15 \(Frequency Response vs Capacitive Load.\)](#)

The OPAx354-Q1 topology enhances the ability of the device to drive capacitive loads. In unity gain, these op-amps perform well with large capacitive loads. For details see [Figure 5-14, Recommended \$R_S\$ vs Capacitive Load](#), and [Figure 5-15, Frequency Response vs Capacitive Load](#).

Insert a 10Ω to 20Ω resistor in series with the output to improve capacitive load drive in the unity-gain configuration, as shown in [Figure 6-6](#). This configuration significantly reduces ringing with large capacitive loads; see [Figure 5-15 \(Frequency Response vs Capacitive Load.\)](#) However, if a resistive load is in parallel with the capacitive load, R_S creates a voltage divider. This configuration introduces a DC error at the output and slightly reduces output swing. This error may be insignificant. For example, if $R_L = 10\text{k}\Omega$ and $R_S = 20\Omega$, the error at the output is approximately 0.2%.

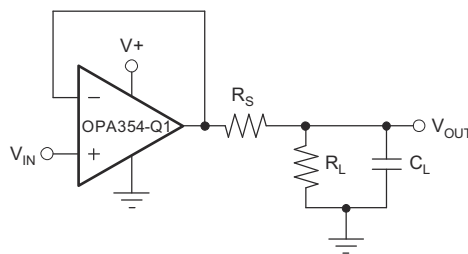


Figure 6-6. Series Resistor in Unity-Gain Configuration Improves Capacitive Load Drive

6.3.8 Wideband Transimpedance Amplifier

Wide bandwidth, low-input bias current, and low input voltage and current noise make the OPAx354-Q1 family of devices is designed as a wideband photodiode transimpedance amplifier for low-voltage single-supply applications. Low-voltage noise is important because photodiode capacitance causes the effective noise gain of the circuit to increase at high frequency.

The key elements to a transimpedance design, as shown in [Figure 6-7](#), are the expected diode capacitance [including the parasitic input common-mode and differential-mode input capacitance (2 + 2) pF for the OPAx354-Q1], the desired transimpedance gain (R_F), and the gain-bandwidth product (GBW) for the OPAx354-Q1 family

of devices (100MHz). With these three variables set, the feedback capacitor value (C_F) is set to control the frequency response.

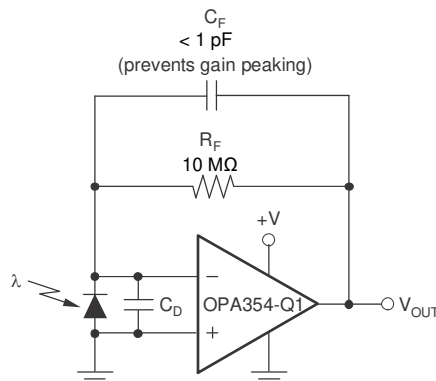


Figure 6-7. Transimpedance Amplifier

To achieve a maximally flat second-order Butterworth frequency response, set the feedback pole as shown in [Equation 1](#).

$$\frac{1}{2\pi R_F C_F} = \sqrt{\frac{GBP}{4\pi R_F C_D}} \quad (1)$$

Typical surface-mount resistors have a parasitic capacitance of approximately 0.2pF that required deduction from the calculated feedback capacitance value.

Use [Equation 2](#) to calculate the bandwidth.

$$f_{-3dB} = \sqrt{\frac{GBP}{2\pi R_F C_D}} \text{ Hz} \quad (2)$$

For even higher transimpedance bandwidth, use the high-speed CMOS OPA355-Q1 (200MHz GBW) or the OPA655-Q1 (400MHz GBW).

6.4 Device Functional Modes

The OPAx354-Q1 family of devices is powered on when the supply is connected. The devices operates as a single-supply operational amplifier or dual-supply amplifier depending on the application. The devices are used with asymmetrical supplies as long as the differential voltage (V_- to V_+) is at least 1.8V and no greater than 5.5V (example: V_- set to $-3.5V$ and V_+ set to $1.5V$).

7 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

7.1 Application Information

The OPAx354-Q1 family of devices is a CMOS, rail-to-rail I/O, high-speed, voltage-feedback operational amplifier designed for video, high-speed, and other applications. The OPAx354-Q1 family of devices is available as a single, dual, or quad op-amp.

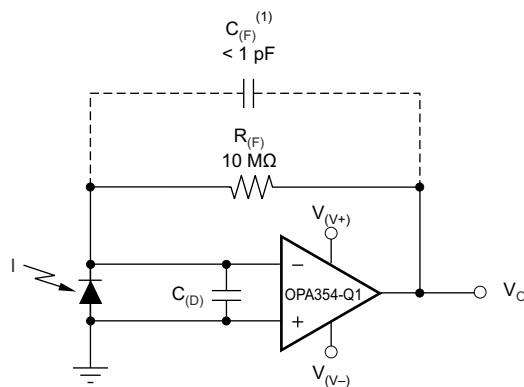
The amplifier features a 100MHz gain bandwidth, and 150V/ μ s slew rate, but the device is unity-gain stable and operates as a 1V/V voltage follower.

7.2 Typical Applications

7.2.1 Transimpedance Amplifier

Wide gain bandwidth, low input bias current, low input voltage, and current noise make the OPAx354-Q1 family of devices a preferred wideband photodiode transimpedance amplifier. Low-voltage noise is important because photodiode capacitance causes the effective noise gain of the circuit to increase at high frequency.

The key elements to a transimpedance design, as shown in [Figure 7-1](#), are the expected diode capacitance ($C_{(D)}$), which must include the parasitic input common-mode and differential-mode input capacitance (4pF + 5pF); the desired transimpedance gain ($R_{(FB)}$); and the gain-bandwidth (GBW) for the OPAx354-Q1 family of devices (20MHz). With these three variables set, the feedback capacitor value ($C_{(FB)}$) is set to control the frequency response. $C_{(FB)}$ includes the stray capacitance of $R_{(FB)}$, which is 0.2pF for a typical surface-mount resistor.



A. $C_{(FB)}$ is optional to prevent gain peaking. $C_{(FB)}$ includes the stray capacitance of $R_{(FB)}$.

Figure 7-1. Dual-Supply Transimpedance Amplifier

7.2.1.1 Design Requirements

PARAMETER	VALUE
Supply voltage $V_{(V+)}$	2.5V
Supply voltage $V_{(V-)}$	-2.5V

7.2.1.2 Detailed Design Procedure

To achieve a maximally-flat, second-order Butterworth frequency response, the feedback pole must be set to:

$$\frac{1}{2 \times \pi \times R_{(FB)} \times C_{(FB)}} = \sqrt{\frac{GBW}{4 \times \pi \times R_{(FB)} \times C_{(D)}}} \quad (3)$$

Use Equation 4 to calculate the bandwidth.

$$f_{(-3 \text{ dB})} = \sqrt{\frac{GBW}{2 \times \pi \times R_{(FB)} \times C_{(D)}}} \quad (4)$$

For other transimpedance bandwidths, consider the high-speed CMOS OPA380 (90MHz GBW), OPA354 (100MHz GBW), OPA300 (180MHz GBW), OPA355 (200MHz GBW), or OPA656 and OPA657 (400MHz GBW).

For single-supply applications, the +INx input can be biased with a positive DC voltage to allow the output to reach true zero when the photodiode is not exposed to any light, and respond without the added delay that results from coming out of the negative rail; this configuration is shown in Figure 7-2. This bias voltage appears across the photodiode, providing a reverse bias for faster operation.

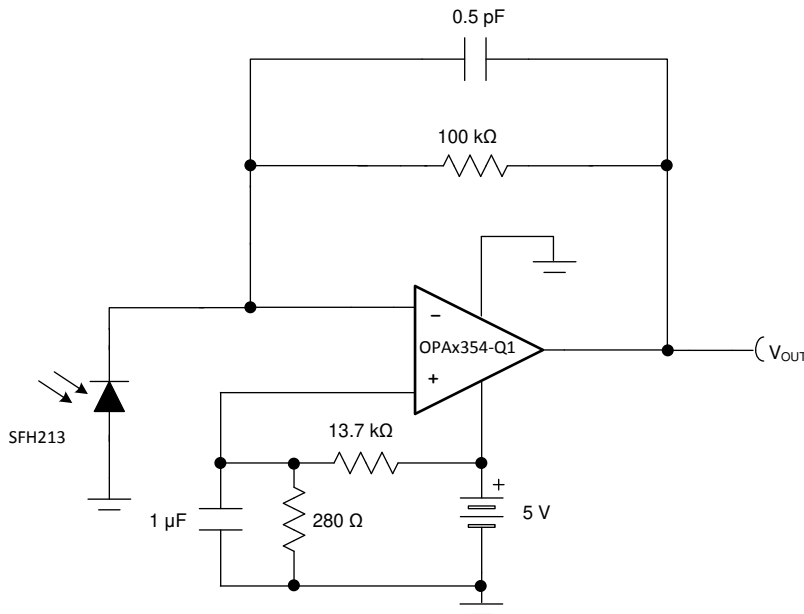


Figure 7-2. Single-Supply Transimpedance Amplifier

For additional information, see the [Compensate Transimpedance Amplifiers Intuitively](#) application bulletin.

7.2.1.2.1 Optimizing The Transimpedance Circuit

To achieve the best performance, components must be selected according to the following guidelines:

1. For lowest noise, select $R_{(FB)}$ to create the total required gain. Using a lower value for $R_{(FB)}$ and adding gain after the transimpedance amplifier generally produces poorer noise performance. The noise produced by $R_{(FB)}$ increases with the square-root of $R_{(FB)}$, whereas the signal increases linearly. Therefore, signal-to-noise ratio improves when all the required gain is placed in the transimpedance stage.
2. Minimize photodiode capacitance and stray capacitance at the summing junction (inverting input). This capacitance causes the voltage noise of the op amp to be amplified (increasing amplification at high frequency). Using a low-noise voltage source to reverse-bias a photodiode can significantly reduce the

capacitance. Smaller photodiodes have lower capacitance. Use optics to concentrate light on a small photodiode.

3. Noise increases with increased bandwidth. Limit the circuit bandwidth to only that required. Use a capacitor across the $R_{(FB)}$ to limit bandwidth, even if not required for stability.
4. Circuit board leakage can degrade the performance of an otherwise well-designed amplifier. Clean the circuit board carefully. A circuit board guard trace that encircles the summing junction and is driven at the same voltage can help control leakage.

For additional information, see the [Noise Analysis of FET Transimpedance Amplifiers](#), and [Noise Analysis for High-Speed Op Amps](#) application bulletins.

7.2.1.3 Application Curve

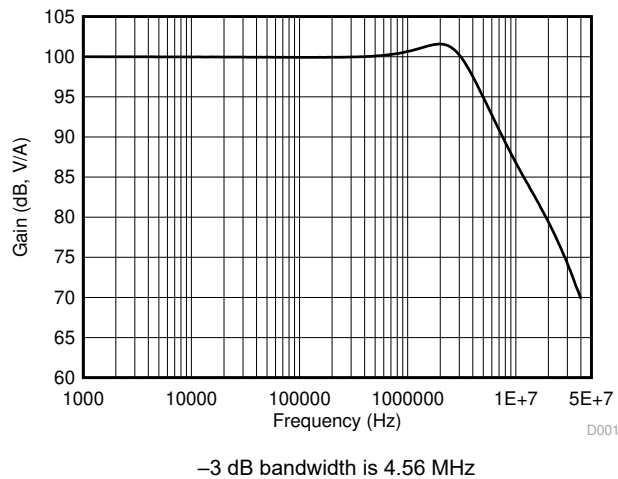


Figure 7-3. AC Transfer Function

7.2.2 High-Impedance Sensor Interface

Many sensors have high source impedances that may range up to 10M Ω , or even higher. The output signal of sensors often must be amplified or otherwise conditioned by an amplifier. The input bias current of this amplifier can load the sensor output and cause a voltage drop across the source resistance, as shown in [Figure 7-4](#), where $V_{(+INx)} = V_S - I_{(BIAS)} \times R_{(S)}$. The last term, $I_{(BIAS)} \times R_{(S)}$, shows the voltage drop across $R_{(S)}$. To prevent errors introduced to the system as a result of this voltage, use an op amp with low input bias current and high-impedance sensors. This low current keeps the error contribution by $I_{(BIAS)} \times R_{(S)}$ less than the input voltage noise of the amplifier, so that the amplifier does not become the dominant noise factor. The OPax354-Q1 family of devices series of op amps feature low input bias current (typically 200fA), and are therefore designed for such applications.

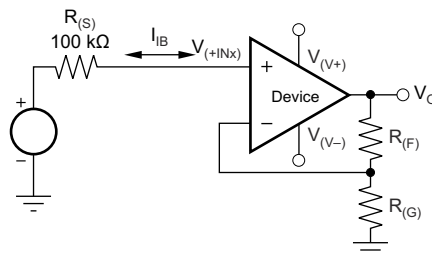
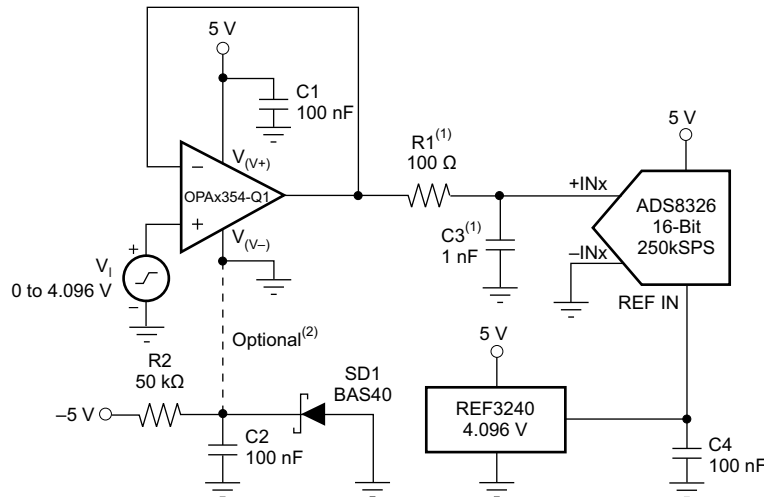


Figure 7-4. Noise as a Result of $I_{(BIAS)}$

7.2.3 Driving ADCs

The OPAx354-Q1 op amps are designed for driving sampling analog-to-digital converters (ADCs) with sampling speeds up to 1MSPS. The zero-crossover distortion input stage topology allows the OPAx354-Q1 family of devices to drive ADCs without degradation of differential linearity and THD.

The OPAx354-Q1 family of devices can be used to buffer the ADC switched input capacitance and resulting charge injection while providing signal gain. Figure 7-5 shows the OPAx354-Q1 family of devices configured to drive the ADS8326.



- A. Suggested value; may require adjustment based on specific application.
- B. Single-supply applications lose a small number of ADC codes near ground as a result of op amp output swing limitation. If a negative power supply is available, this simple circuit creates a -0.3V supply to allow output swing to true ground potential.

Figure 7-5. Driving the ADS8326

7.2.4 Active Filter

The OPAx354-Q1 family of devices is designed for active filter applications that require a wide bandwidth, fast slew rate, low-noise, single-supply operational amplifier. Figure 7-6 shows a 500kHz, second-order, low-pass filter using the multiple-feedback (MFB) topology. The components are selected to provide a maximally-flat Butterworth response. Beyond the cutoff frequency, roll-off is -40dB/dec. The Butterworth response is designed for applications requiring predictable gain characteristics, such as the anti-aliasing filter used in front of an ADC.

One point to observe when considering the MFB filter is that the output is inverted relative to the input. If this inversion is not required, or not desired, a noninverting output can be achieved through one of the following options:

1. Adding an inverting amplifier
2. Adding an additional second-order MFB stage
3. Using a noninverting filter topology, such as the Sallen-Key (see Figure 7-7).

MFB and Sallen-Key, low-pass and high-pass filter synthesis is accomplished using TI's FilterPro™ program. This software is available as a free download on www.ti.com.

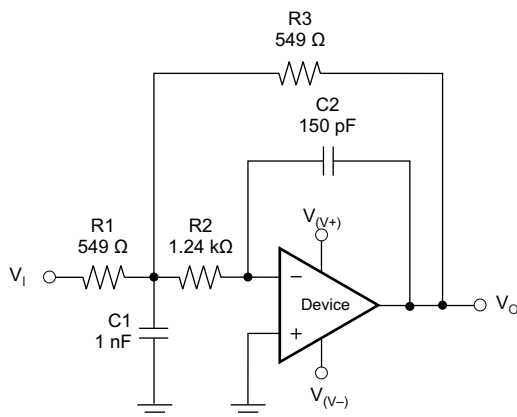


Figure 7-6. Second-Order Butterworth 500kHz Low-Pass Filter

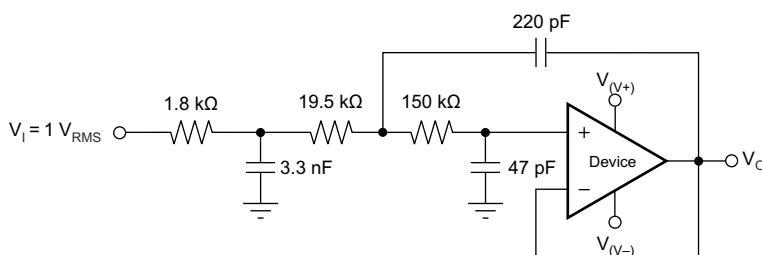


Figure 7-7. OPAx354-Q1 Configured as a Three-Pole, 20kHz, Sallen-Key Filter

7.3 Power Supply Recommendations

The OPAx354-Q1 family of devices is specified for operation from 2.5V to 5.5V ($\pm 1.25\text{V}$ to $\pm 2.75\text{V}$); many specifications apply from -40°C to $+125^\circ\text{C}$. Parameters that can exhibit significant variance with regard to operating voltage or temperature are shown in [Section 5.6](#).

CAUTION

Supply voltages larger than 7.5V can permanently damage the device (see the [Section 5.1](#) table).

Place 0.1 μF bypass capacitors close to the power-supply pins to reduce errors coupling in from noisy or high-impedance power supplies. For more detailed information on bypass capacitor placement, see [Section 7.4.1](#).

7.3.1 Power Dissipation

Power dissipation depends on power-supply voltage, signal and load conditions. With dc signals, power dissipation is equal to the product of output current times the voltage across the conducting output transistor ($V_S - V_O$). Minimize power dissipation by using the lowest possible power-supply voltage required to ensure the required output voltage swing.

For resistive loads, the maximum power dissipation occurs at a DC output voltage of one-half the power-supply voltage. Dissipation with AC signals is lower. The [Power Amplifier Stress and Power Handling Limitations](#) application bulletin from www.ti.com explains how to calculate or measure power dissipation with unusual signals and loads.

Any tendency to activate the thermal protection circuit indicates excessive power dissipation or an inadequate heat sink. For reliable operation, limit junction temperature to 150°C, maximum. To estimate the margin of safety in a complete design, increase the ambient temperature to trigger the thermal protection at 160°C. The thermal protection must trigger more than 35°C above the maximum expected ambient condition of the application.

7.4 Layout

7.4.1 Layout Guidelines

Use good high-frequency printed circuit board (PCB) layout techniques for the OPAx354-Q1 family of devices. Generous use of ground planes, short and direct signal traces, and a suitable bypass capacitor located at the V+ pin ensure clean, stable operation. Large areas of copper provide a means of dissipating heat that is generated in normal operation. Sockets are not recommended for use with any high-speed amplifier. A 10nF ceramic bypass capacitor is the minimum recommended value; adding a 1μF or larger tantalum capacitor in parallel can be beneficial when driving a low-resistance load. Providing adequate bypass capacitance is essential to achieving very low harmonic and intermodulation distortion.

For best operational performance of the device, use good PCB layout practices, including:

- Noise can propagate into analog circuitry through the power pins of the circuit as a whole and the operational amplifier. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
 - Connect low-ESR, 0.1μF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single-supply applications.
- Separate grounding for analog and digital portions of the circuitry is one of the simplest and most effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds, paying attention to the flow of the ground current. For more detailed information, see [Circuit Board Layout Techniques](#).
- To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If these traces cannot be kept separate, crossing the sensitive trace perpendicularly is much better than crossing in parallel with the noisy trace.
- Place the external components as close to the device as possible. Keeping RF and RG close to the inverting input minimizes parasitic capacitance, as shown in [Figure 7-8](#).
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.

7.4.2 Layout Example

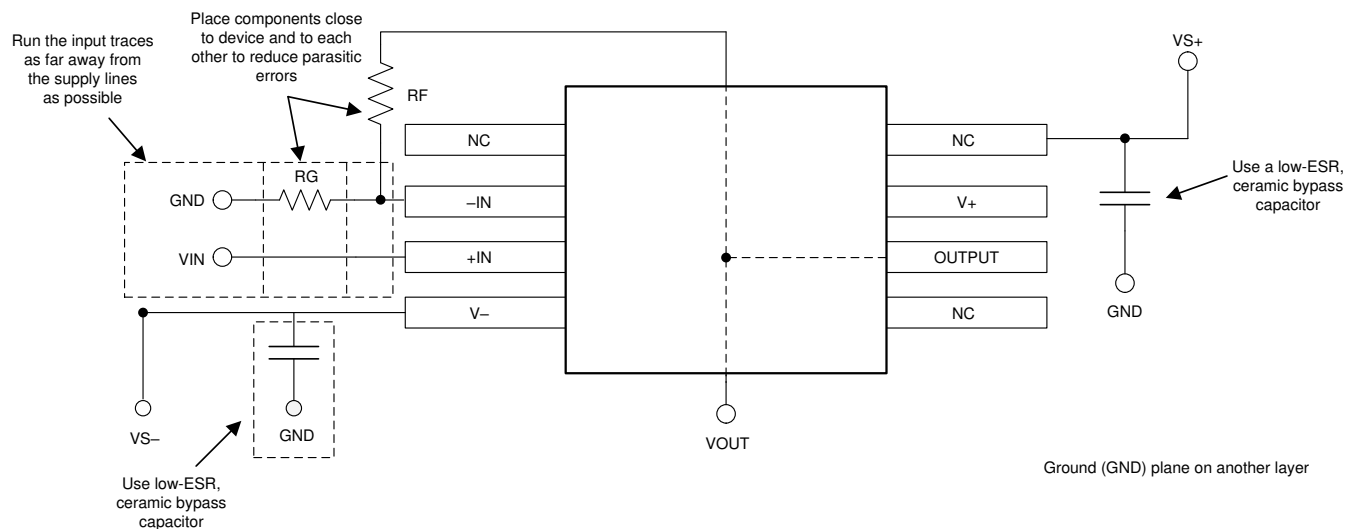


Figure 7-8. Operational Amplifier Board Layout for Noninverting Configuration

8 Device and Documentation Support

8.1 Documentation Support

8.1.1 Related Documentation

For related documentation see the following:

- Texas Instruments, [ADS8326 16-Bit, High-Speed, 2.7V to 5.5V microPower Sampling Analog-to-Digital Converter](#)
- Texas Instruments, [Circuit Board Layout Techniques](#)
- Texas Instruments, [Compensate Transimpedance Amplifiers Intuitively](#)
- Texas Instruments, [FilterPro™ User's Guide](#)
- Texas Instruments, [Noise Analysis of FET Transimpedance Amplifiers](#)
- Texas Instruments, [Noise Analysis for High-Speed Op Amps](#)
- Texas Instruments, [OPA380 and OPA2380 Precision, High-Speed Transimpedance Amplifier](#)
- Texas Instruments, [OPA354, OPA2354, and OPA4354 250MHz, Rail-to-Rail I/O, CMOS Operational Amplifiers](#)
- Texas Instruments, [OPA355, OPA2355, and OPA3355 200MHz, CMOS Operational Amplifier With Shutdown](#)
- Texas Instruments, [OPA656 Wideband, Unity-Gain Stable, FET-Input Operational Amplifier](#)
- Texas Instruments, [Power Amplifier Stress and Power Handling Limitations](#)

8.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

8.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

8.4 Trademarks

FilterPro™ is a trademark of Texas Instruments Incorporated.

TI E2E™ is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

8.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

9 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision F (May 2018) to Revision G (August 2026)	Page
• Deleted ESD information in Features.....	1
• Updated the numbering format for tables, figures, and cross-references throughout the document.....	1
• Updated Thermal Information for OPA354A-Q1 DBV package.....	5
• Updated Input current noise, rise & fall time, open-loop output resistance, quiescent current in Electrical Characteristics for OPA354A-Q1.....	6
• Updated plots in Typical Characteristics.....	8

Changes from Revision E (August 2016) to Revision F (May 2018)	Page
• Deleted table note about input terminals and input signals from Absolute Maximum Ratings table.....	5

Changes from Revision D (July 2016) to Revision E (August 2016)	Page
• Changed the gain-bandwidth product typical value from 10MHz back to 100MHz in the Electrical Characteristics table.....	6

Changes from Revision C (June 2016) to Revision D (July 2016)	Page
• Changed the gain-bandwidth product typical value from 100MHz to 10MHz in the Electrical Characteristics table.....	6

Changes from Revision B (December 2014) to Revision C (June 2016)	Page
• Added 3 additional applications to the <i>Applications</i> section	1
• Updated ESD Ratings table to show CDM value for OPA354A-Q1 and OPA2354A-Q1.....	5

Changes from Revision A (August 2009) to Revision B (December 2014)	Page
• Added <i>Handling Rating</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section.....	1
• Added the OPA4354-Q1 device to the data sheet	1
• Updated channel-to-channel crosstalk in Specifications table.....	6

10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
OPA2354AQDGKRQ1	Active	Production	VSSOP (DGK) 8	2500 LARGE T&R	Yes	Call TI Nipdauag Nipdau	Level-2-260C-1 YEAR	-40 to 125	OSLQ
OPA2354AQDGKRQ1.B	Active	Production	VSSOP (DGK) 8	2500 LARGE T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 125	OSLQ
OPA354AQDBVRQ1	Active	Production	SOT-23 (DBV) 5	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OSFQ
OPA354AQDBVRQ1.A	Active	Production	SOT-23 (DBV) 5	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OSFQ
OPA354AQDBVRQ1.B	Active	Production	SOT-23 (DBV) 5	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OSFQ
OPA4354AQPWRQ1	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	4354Q1
OPA4354AQPWRQ1.A	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	4354Q1
OPA4354AQPWRQ1.B	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	4354Q1

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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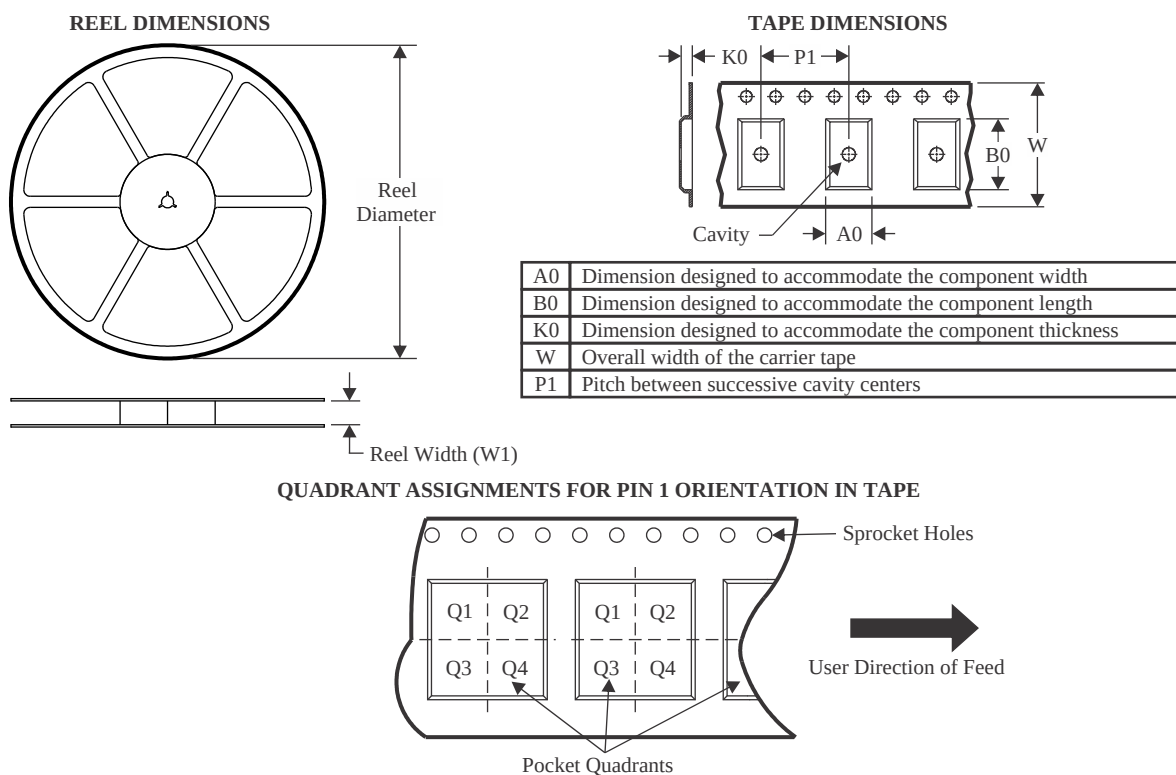
OTHER QUALIFIED VERSIONS OF OPA4354-Q1 :

- Catalog : [OPA4354](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

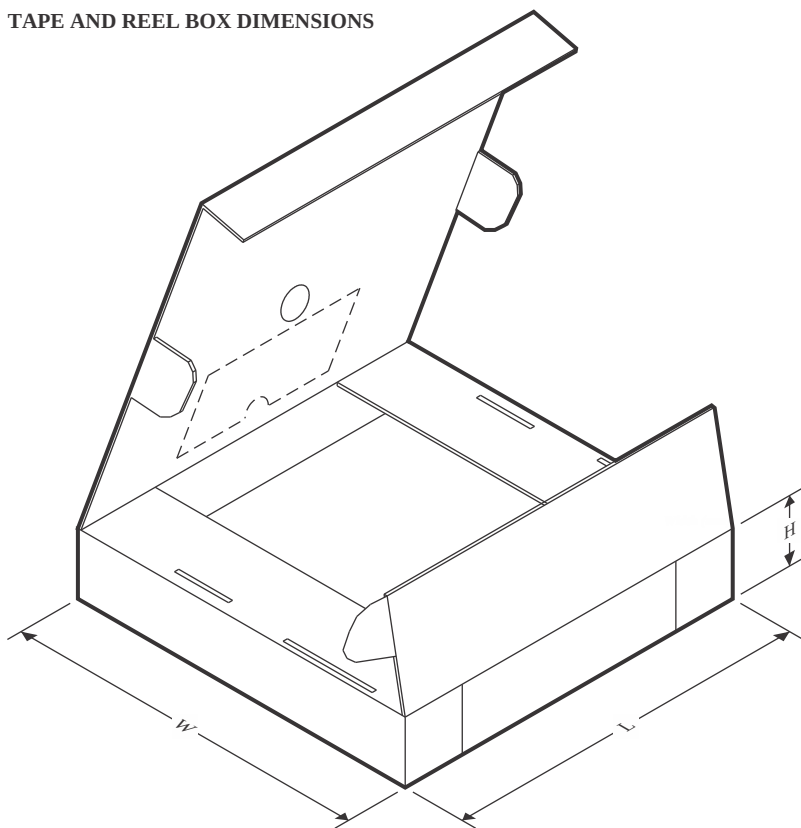
TAPE AND REEL INFORMATION



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
OPA2354AQDGKRQ1	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2354AQDGKRQ1	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA354AQDBVRQ1	SOT-23	DBV	5	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
OPA4354AQPWRQ1	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

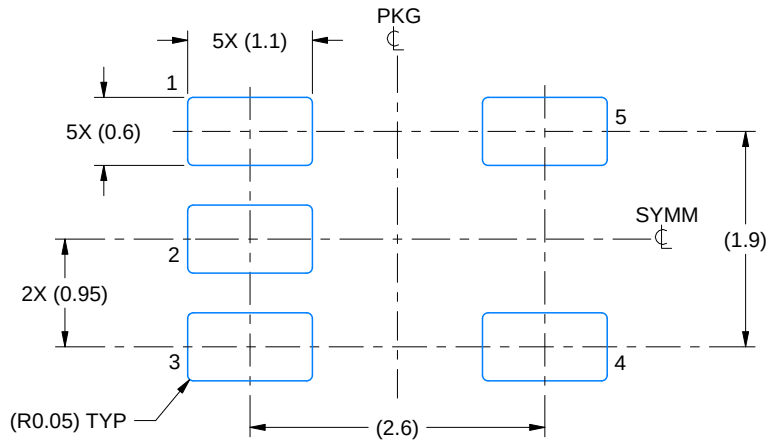
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
OPA2354AQDGKRQ1	VSSOP	DGK	8	2500	353.0	353.0	32.0
OPA2354AQDGKRQ1	VSSOP	DGK	8	2500	367.0	367.0	35.0
OPA354AQDBVRQ1	SOT-23	DBV	5	3000	213.0	191.0	35.0
OPA4354AQPWRQ1	TSSOP	PW	14	2000	353.0	353.0	32.0

EXAMPLE BOARD LAYOUT

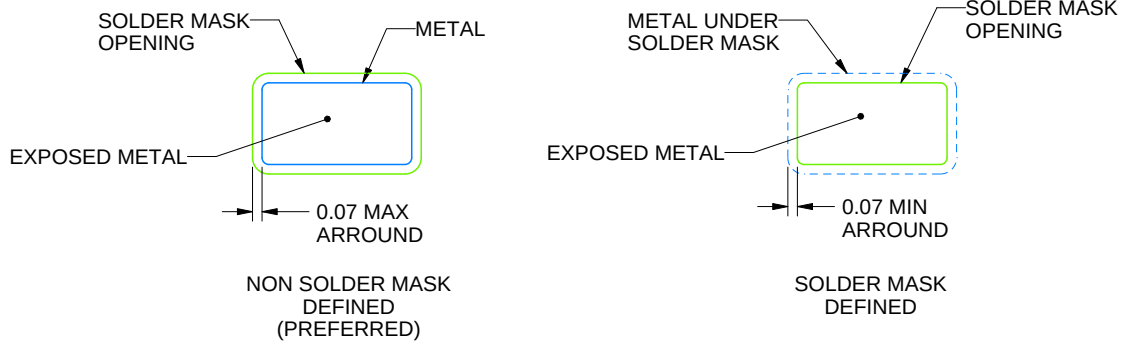
DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



SOLDER MASK DETAILS

4214839/K 08/2024

NOTES: (continued)

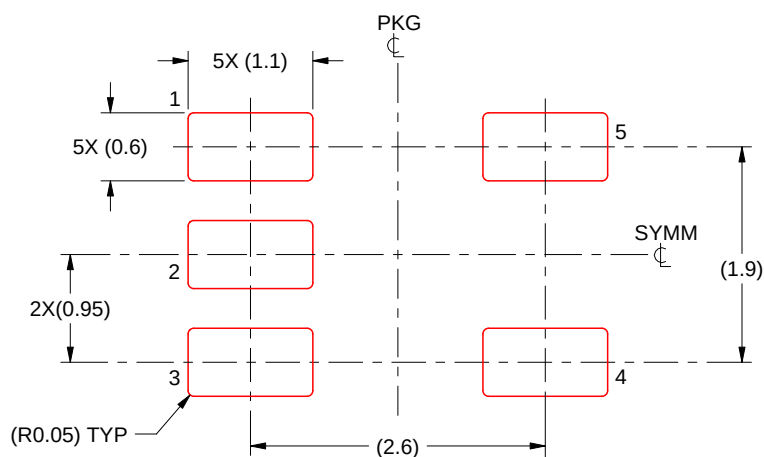
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR

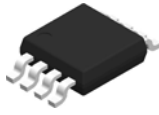


SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

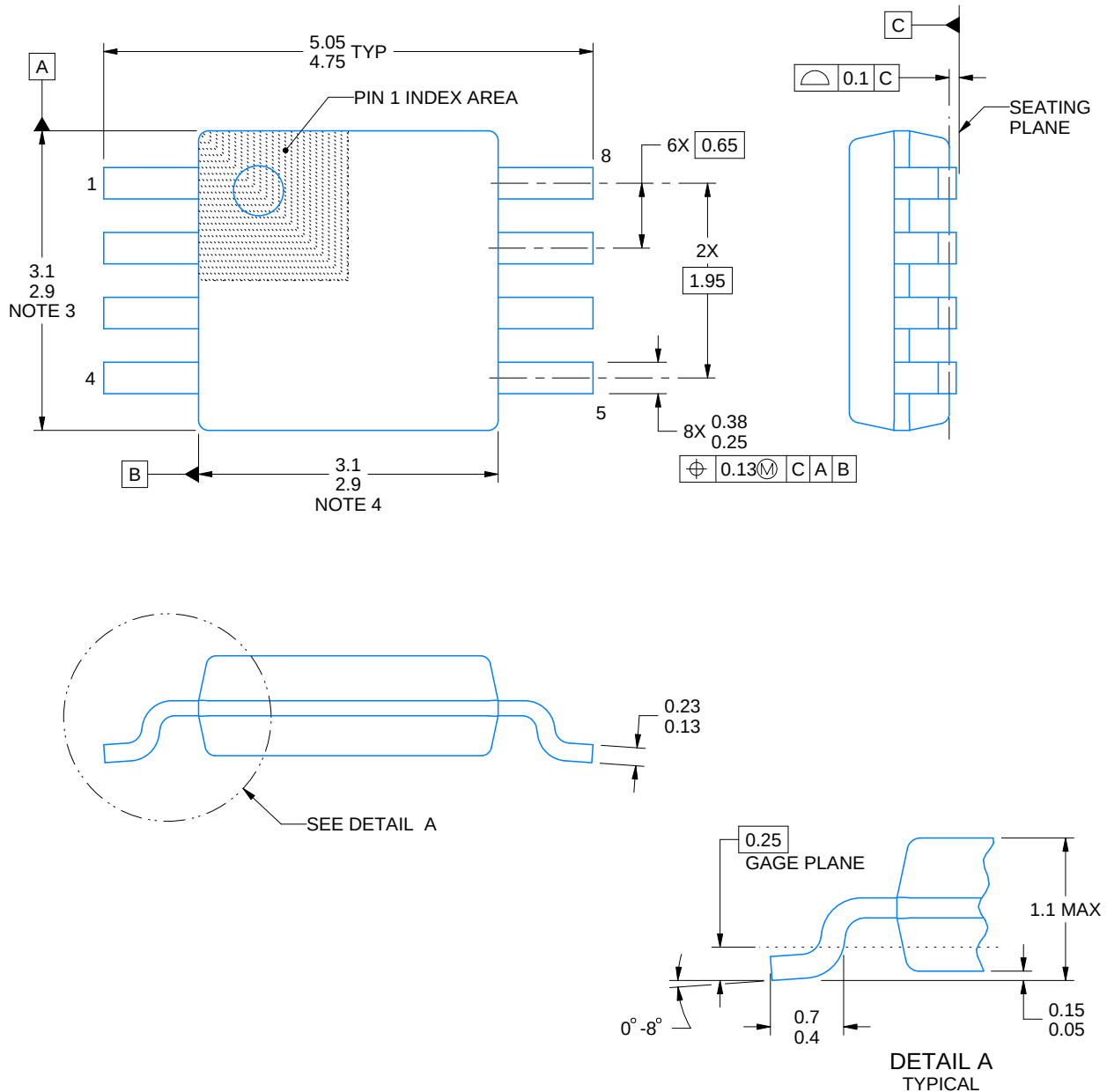
4214839/K 08/2024

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

DGK0008A**PACKAGE OUTLINE****VSSOP - 1.1 mm max height**

SMALL OUTLINE PACKAGE



4214862/A 04/2023

NOTES:

PowerPAD is a trademark of Texas Instruments.

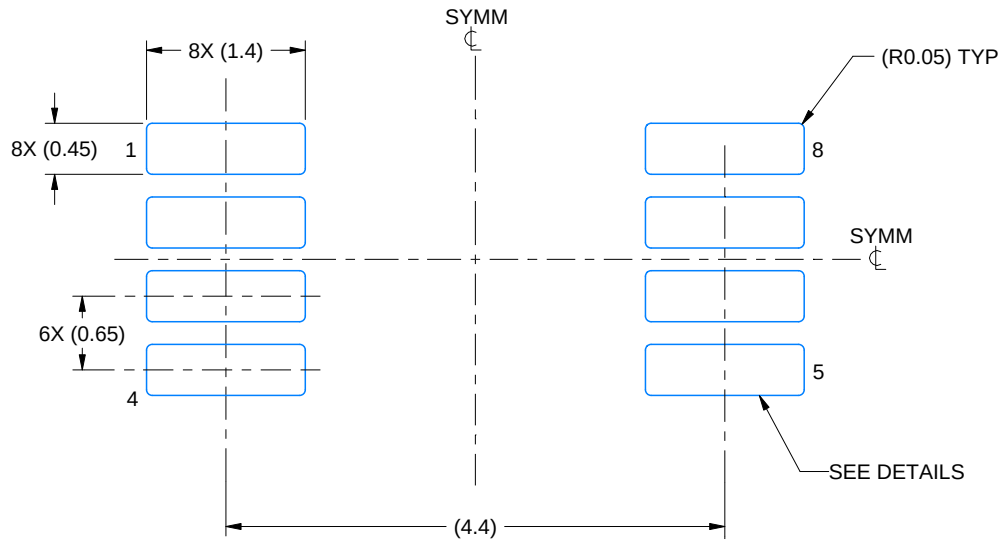
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-187.

EXAMPLE BOARD LAYOUT

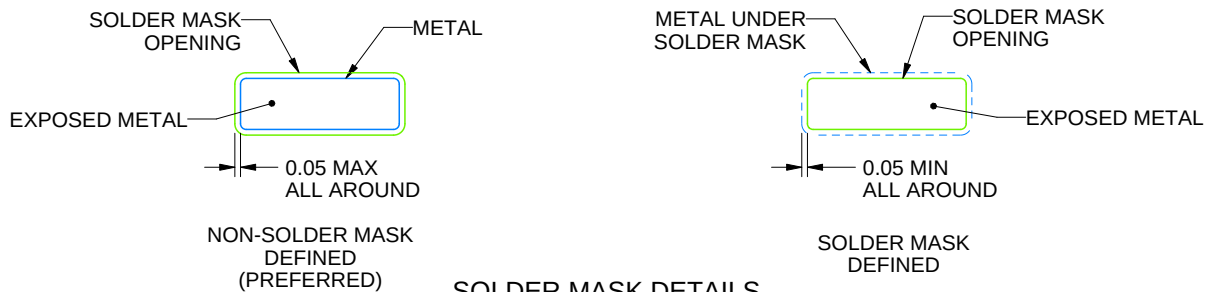
DGK0008A

TM VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X



SOLDER MASK DETAILS

4214862/A 04/2023

NOTES: (continued)

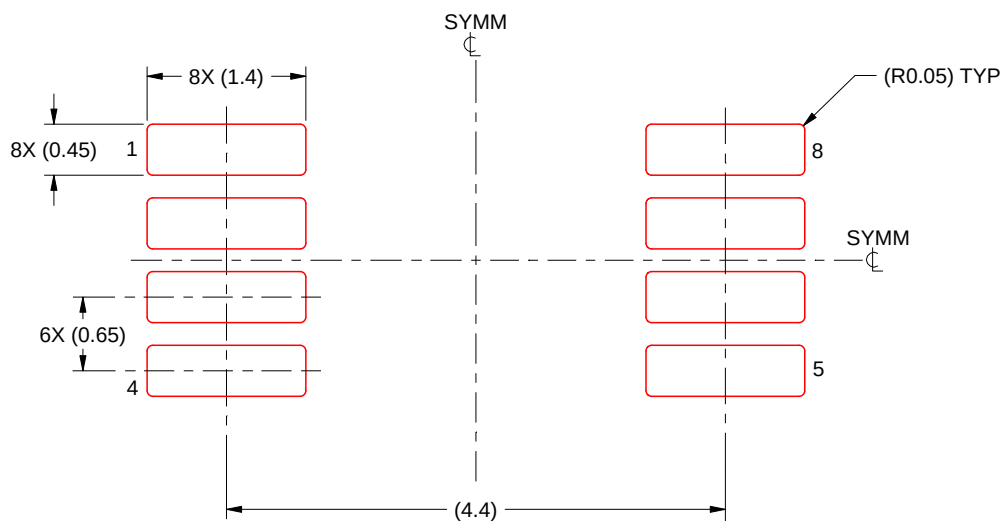
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.
9. Size of metal pad may vary due to creepage requirement.

EXAMPLE STENCIL DESIGN

DGK0008A

TM VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
SCALE: 15X

4214862/A 04/2023

NOTES: (continued)

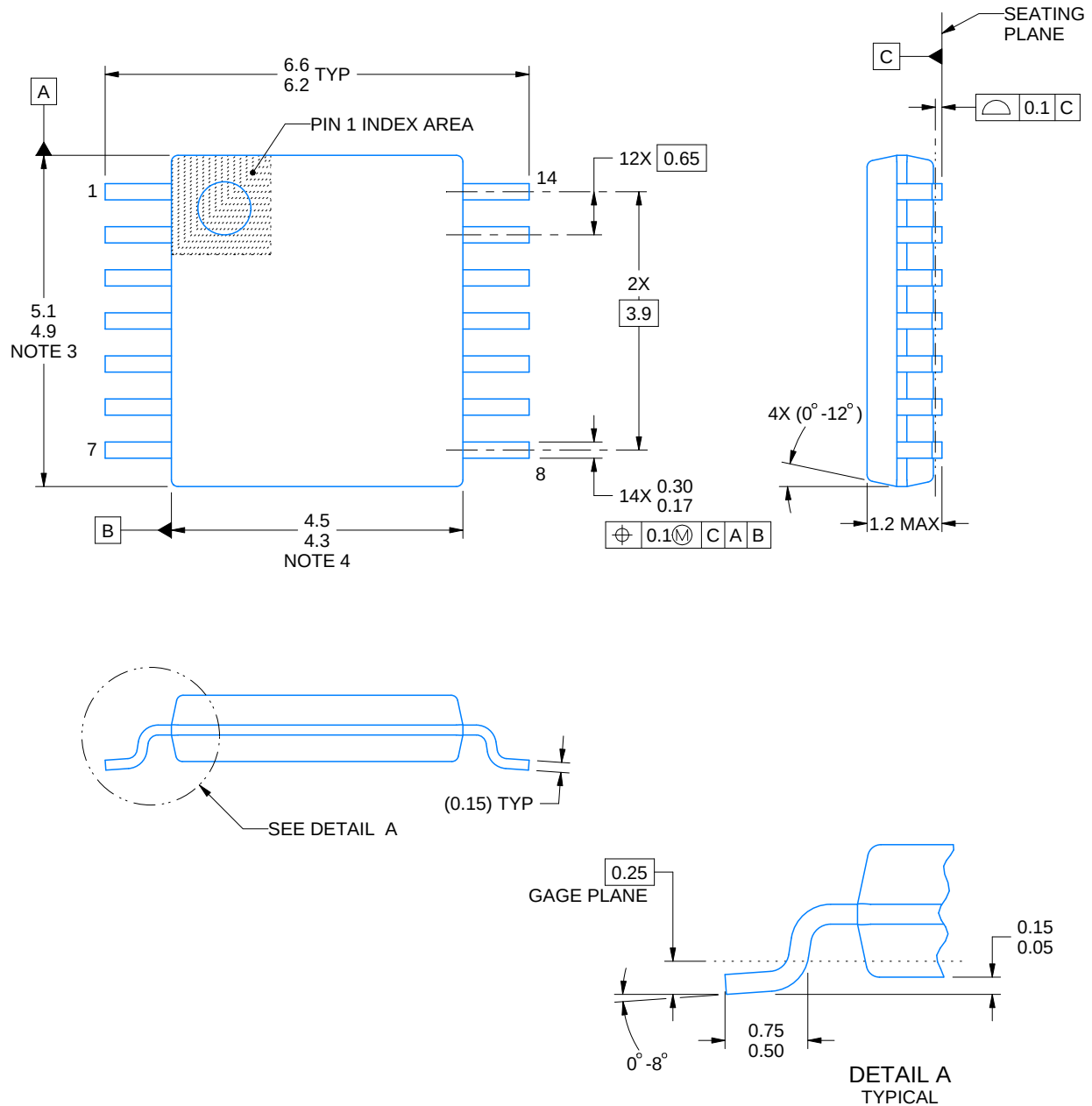
11. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
12. Board assembly site may have different recommendations for stencil design.

PW0014A

PACKAGE OUTLINE

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



4220202/B 12/2023

NOTES:

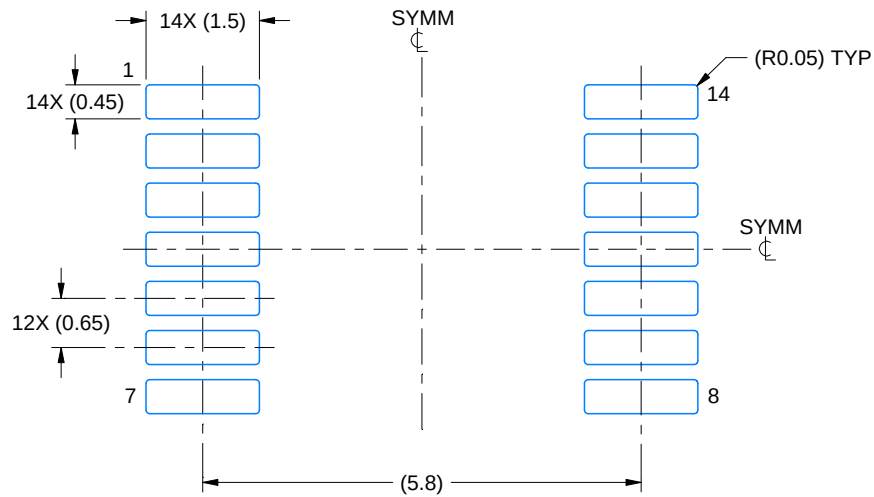
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

EXAMPLE BOARD LAYOUT

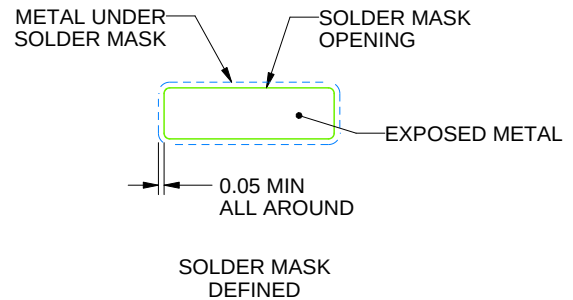
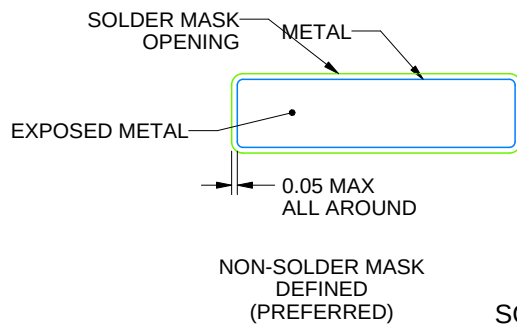
PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

4220202/B 12/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

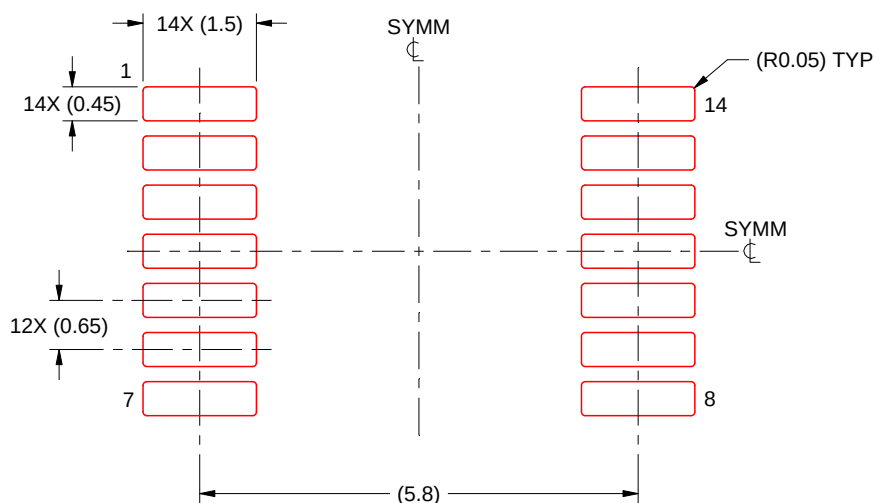
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220202/B 12/2023

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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