

SINGLE-SUPPLY RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

Check for Samples: [OPA340-EP](#)

FEATURES

- Rail-to-Rail Input
- Rail-to-Rail Output (Within 1 mV)
- Wide Bandwidth: 5.5 MHz
- High Slew Rate: 6 V/ μ s
- Low THD+Noise: 0.0007% ($f = 1$ kHz)
- Low Quiescent Current: 750 μ A/channel
- Single, Dual, and Quad Versions

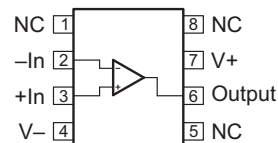
APPLICATIONS

- Driving Analog-to-Digital (A/D) Converters
- PCMCIA Cards
- Data Acquisition
- Process Control
- Audio Processing
- Communications
- Active Filters
- Test Equipment

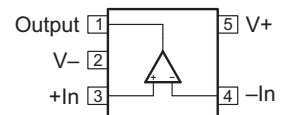
SUPPORTS DEFENSE, AEROSPACE, AND MEDICAL APPLICATIONS

- Controlled Baseline
- One Assembly/Test Site
- One Fabrication Site
- Available in Military ($-55^{\circ}\text{C}/125^{\circ}\text{C}$) Temperature Range⁽¹⁾
- Extended Product Life Cycle
- Extended Product-Change Notification
- Product Traceability

D PACKAGE
(TOP VIEW)



DBV PACKAGE
(TOP VIEW)



NC – No internal connection

(1) Additional temperature ranges are available - contact factory

DESCRIPTION

The OPA340 rail-to-rail CMOS operational amplifier is optimized for low-voltage, single-supply operation. Rail-to-rail input/output and high-speed operation make it ideal for driving sampling analog-to-digital (A/D) converters. The OPA340 is also well-suited for general purpose and audio applications as well as providing current/voltage conversion at the output of digital-to-analog (D/A) converters.

The OPA340 operates on a single supply as low as 2.7 V with an input common-mode voltage range that extends 500 mV below ground and 500 mV above the positive supply. Output voltage swing is to within 1 mV of the supply rails with a 100-k Ω load. It offers excellent dynamic response ($BW = 5.5$ MHz, $SR = 6$ V/ μ s), yet quiescent current is only 750 μ A.

The surface mount package options are SOIC-8 or SOT23-5. Both are specified from -55°C to 125°C . A SPICE macromodel is available for design analysis.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



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.

ORDERING INFORMATION⁽¹⁾

T _A	PACKAGE ⁽²⁾		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–55°C to 125°C	SOIC – D (8 pin)	Reel of 2500	OPA340MDREP ⁽³⁾	PREVIEW
	SOT23-5 – DBV	Reel of 250	OPA340MDBVTEP	CVS

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

(3) Product preview. Contact your TI sales representative for availability.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

V _S	Supply voltage	5.5 V
V _I	Signal input voltage ⁽²⁾	(V _–) – 0.5 V to (V ₊) + 0.5 V
V _O	Signal input current ⁽²⁾	10 mA
	Output short-circuit ⁽³⁾	Continuous
T _A	Operating free-air temperature range	–55°C to 125°C
T _{stg}	Storage temperature range	–55°C to 125°C
T _J	Operating virtual-junction temperature	150°C

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5 V beyond the supply rails should be current limited to 10 mA or less.

(3) Short-circuit to ground, one amplifier per package.

ELECTRICAL CHARACTERISTICS: $V_S = 2.7\text{ V to }5\text{ V}$

Over specified temperature range ($T_A = -55^\circ\text{C to }125^\circ\text{C}$), $V_S = 5\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S/2$, $V_{OUT} = V_S/2$ (unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
OFFSET VOLTAGE					
Input offset voltage	V_{OS} $V_S = 5\text{ V}$ $T_A = 25^\circ\text{C}$		± 150	± 500	μV
	$T_A = \text{Full range}$			± 1600	μV
vs temperature	dV_{OS}/dT		± 2.5		$\mu\text{V}/^\circ\text{C}$
vs power supply	PSRR		30	150	$\mu\text{V}/\text{V}$
Channel separation, dc			0.2		$\mu\text{V}/\text{V}$
INPUT BIAS CURRENT					
Input bias current	I_B		± 0.2	± 500	pA
Input offset current	I_{OS}		± 0.2	± 600	pA
NOISE					
Input voltage noise, $f = 0.1\text{ kHz to }50\text{ kHz}$			8		μVrms
Input voltage noise density, $f = 1\text{ kHz}$	e_n		25		$\text{nV}/\sqrt{\text{Hz}}$
Current noise density, $f = 1\text{ kHz}$	i_n		3		$\text{fA}/\sqrt{\text{Hz}}$
INPUT VOLTAGE RANGE					
Common-mode voltage range	V_{CM}	-0.3		$(V+) + 0.3$	V
Common-mode rejection ratio	CMRR	$-0.3\text{ V} < V_{CM} < (V+) - 1.8\text{ V}$ $T_A = 25^\circ\text{C}$	78	92	dB
		$T_A = \text{Full range}$	75		dB
	$V_S = 5\text{ V}$, $-0.3\text{ V} < V_{CM} < 5.3\text{ V}$ $T_A = 25^\circ\text{C}$	70	84		dB
	$T_A = \text{Full range}$	64			dB
	$V_S = 2.7\text{ V}$, $-0.3\text{ V} < V_{CM} < 3\text{ V}$ $T_A = 25^\circ\text{C}$	66	80		dB
INPUT IMPEDANCE					
Differential			$10^{13} \parallel 3$		$\Omega \parallel \text{pF}$
Common-mode			$10^{13} \parallel 6$		$\Omega \parallel \text{pF}$
OPEN-LOOP GAIN					
Open-loop voltage gain	A_{OL}	$R_L = 100\text{ k}\Omega$, $10\text{ mV} < V_O < (V+) - 10\text{ mV}$	103	124	dB
		$R_L = 10\text{ k}\Omega$, $70\text{ mV} < V_O < (V+) - 70\text{ mV}$	98	120	dB
		$R_L = 2\text{ k}\Omega$, $250\text{ mV} < V_O < (V+) - 250\text{ mV}$	92	114	dB
FREQUENCY RESPONSE					
Gain-bandwidth product	GBW	$G = 1$		5.5	MHz
Slew rate	SR	$V_S = 5\text{ V}$, $G = 1$, $C_L = 100\text{ pF}$		6	$\text{V}/\mu\text{s}$
Settling time, 0.1%		$V_S = 5\text{ V}$, 2-V Step, $C_L = 100\text{ pF}$		1	μs
Settling time, 0.01%		$V_S = 5\text{ V}$, 2-V Step, $C_L = 100\text{ pF}$		1.6	μs
Overload recovery time		$V_{IN} \cdot G = V_S$		0.2	μs
Total harmonic distortion + noise	THD+N	$V_S = 5\text{ V}$, $V_O = 3\text{ V}_{PP}$ ⁽¹⁾ , $G = 1$, $f = 1\text{ kHz}$		0.0007	%

(1) $V_{OUT} = 0.25\text{ V to }3.25\text{ V}$

ELECTRICAL CHARACTERISTICS: $V_S = 2.7\text{ V}$ to 5 V (continued)

Over specified temperature range ($T_A = -55^\circ\text{C}$ to 125°C), $V_S = 5\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S/2$, $V_{OUT} = V_S/2$ (unless otherwise noted)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNIT
OUTPUT						
Voltage output swing from rail ⁽²⁾		R _L = 100 kΩ, A _{OL} ≥ 104 dB		1	10	mV
		R _L = 10 kΩ, A _{OL} ≥ 98 dB		10	70	mV
		R _L = 2 kΩ, A _{OL} ≥ 92 dB		40	250	mV
Short-circuit current	I _{SC}			±50		mA
Capacitive load drive	C _{LOAD}		See Typical Characteristics			
POWER SUPPLY						
Specified voltage range	V _S		2.7		5	V
Operating voltage range			2.5 to 5.5			V
Quiescent current (per amplifier)	I _Q	I _O = 0, V _S = 5 V		750	950	μA
		T _A = 25°C				
		T _A = Full range			1300	μA
TEMPERATURE RANGE						
Specified range			−55		125	°C
Storage range			−55		125	°C
Thermal resistance	θ _{JA}					
DBV (5 pin) package				200		°C/W
D (8 pin) package				150		°C/W

(2) Output voltage swings are measured between the output and power supply rails.

TYPICAL CHARACTERISTICS

At $T_A = 25^\circ\text{C}$, $V_S = 5\text{ V}$, and $R_L = 10\text{ k}\Omega$ connected to $V_S/2$ (unless otherwise noted)

**OPEN-LOOP GAIN/PHASE
vs FREQUENCY**

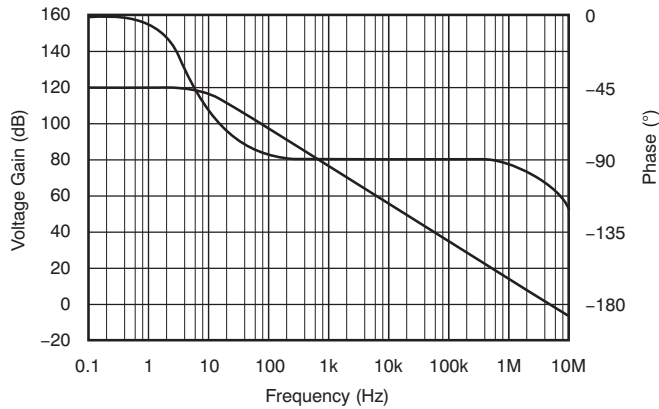


Figure 1.

**POWER-SUPPLY AND COMMON-MODE REJECTION
vs FREQUENCY**

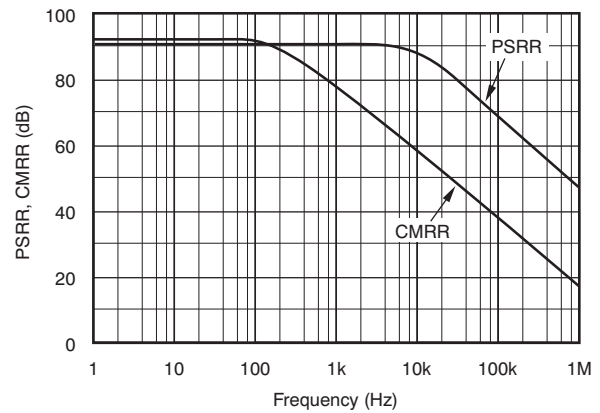


Figure 2.

**INPUT VOLTAGE AND CURRENT NOISE
SPECTRAL DENSITY vs FREQUENCY**

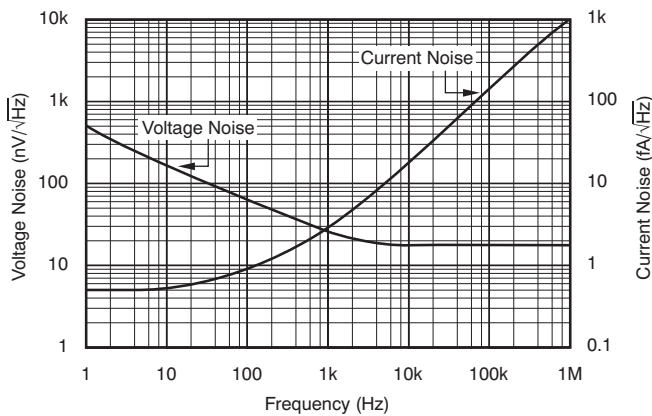


Figure 3.

CHANNEL SEPARATION vs FREQUENCY

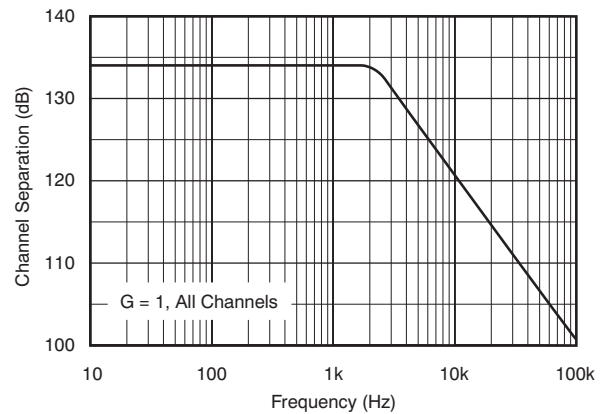


Figure 4.

**TOTAL HARMONIC DISTORTION + NOISE
vs FREQUENCY**

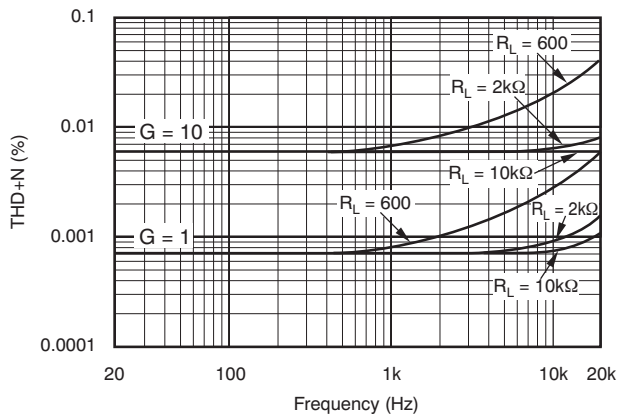


Figure 5.

**CLOSED-LOOP OUTPUT IMPEDANCE
vs FREQUENCY**

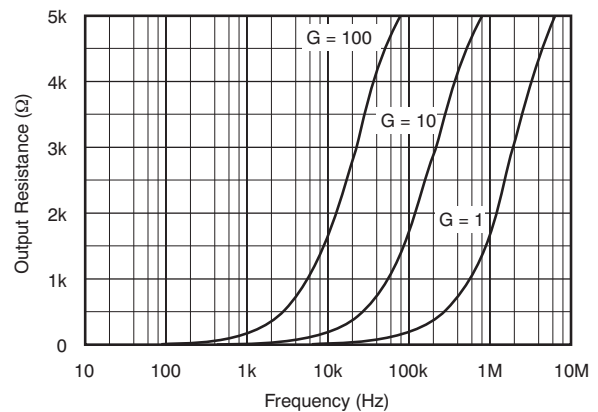


Figure 6.

TYPICAL CHARACTERISTICS (continued)

At $T_A = 25^\circ\text{C}$, $V_S = 5\text{ V}$, and $R_L = 10\text{ k}\Omega$ connected to $V_S/2$ (unless otherwise noted)

OPEN-LOOP GAIN AND POWER-SUPPLY REJECTION vs TEMPERATURE

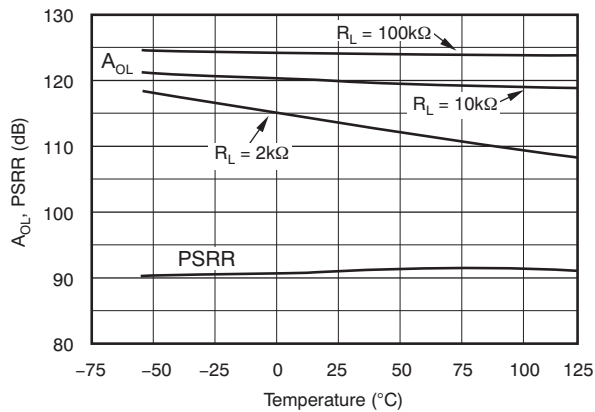


Figure 7.

COMMON-MODE REJECTION vs TEMPERATURE

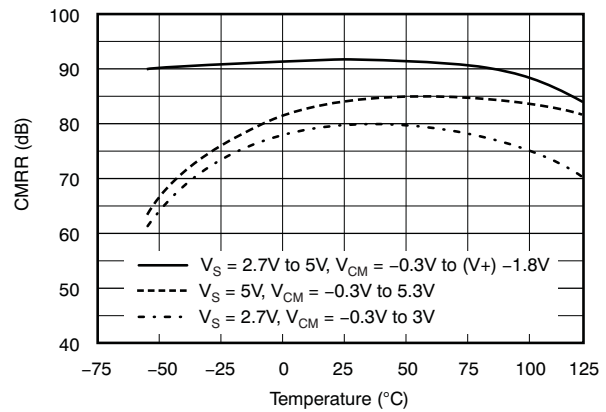


Figure 8.

QUIESCENT CURRENT vs TEMPERATURE

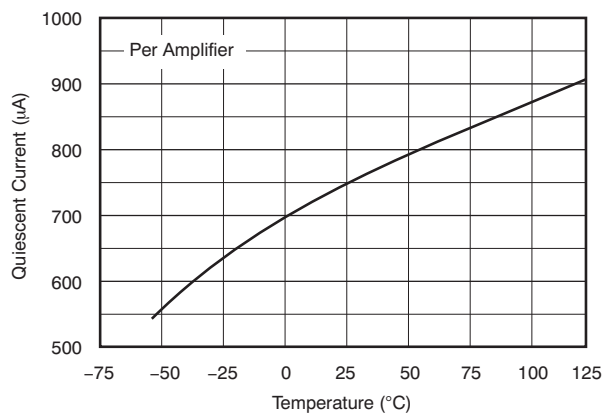


Figure 9.

QUIESCENT CURRENT vs SUPPLY VOLTAGE

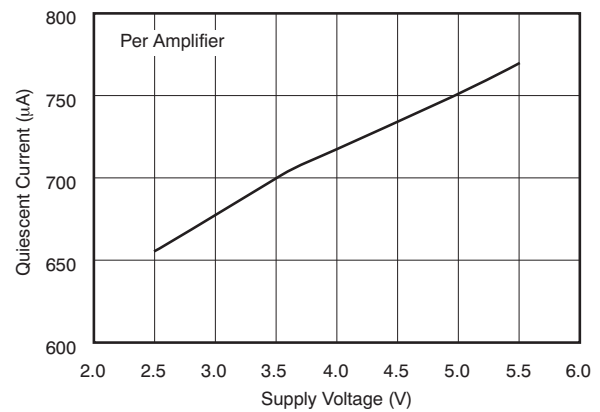


Figure 10.

SHORT-CIRCUIT CURRENT vs TEMPERATURE

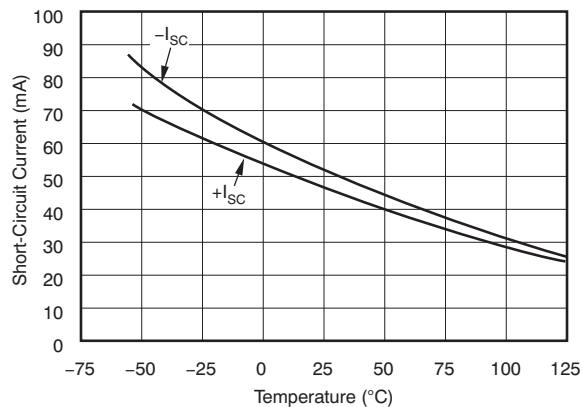


Figure 11.

SHORT-CIRCUIT CURRENT vs SUPPLY VOLTAGE

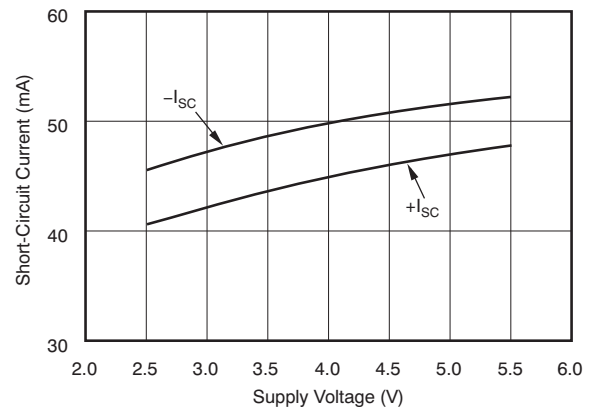


Figure 12.

TYPICAL CHARACTERISTICS (continued)

At $T_A = 25^\circ\text{C}$, $V_S = 5\text{ V}$, and $R_L = 10\text{ k}\Omega$ connected to $V_S/2$ (unless otherwise noted)

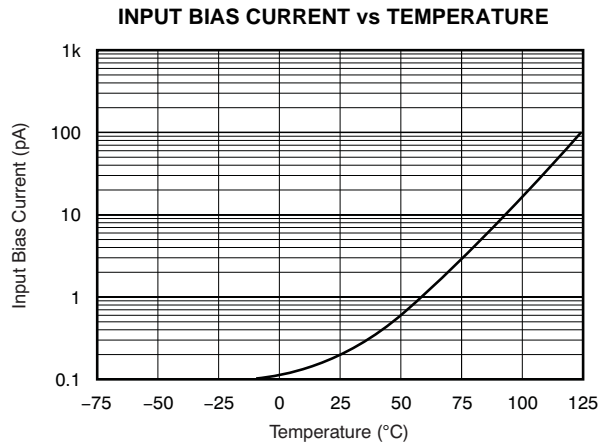


Figure 13.

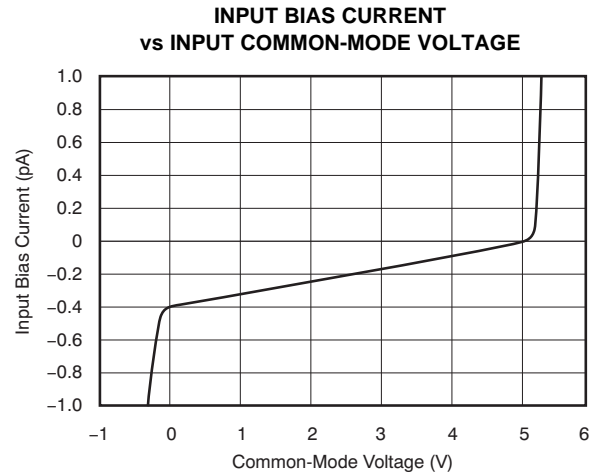


Figure 14.

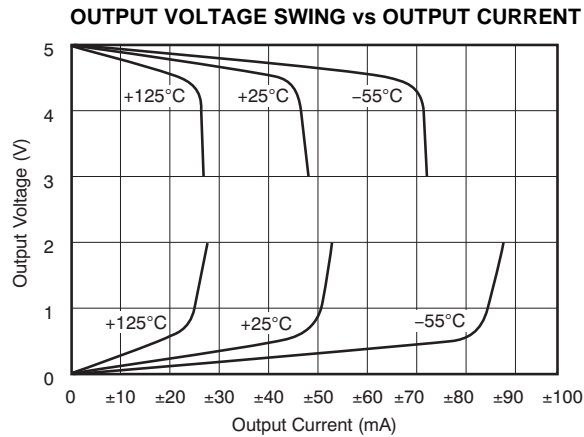


Figure 15.

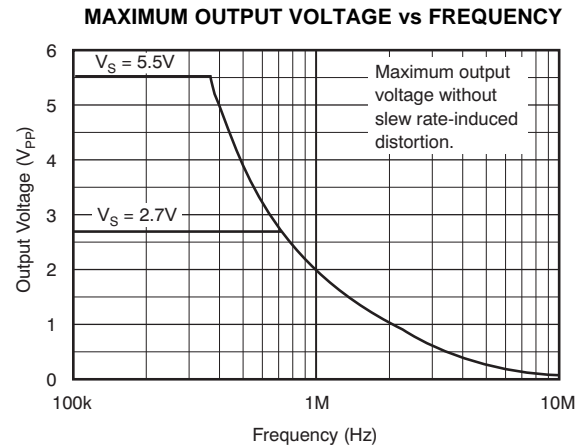


Figure 16.

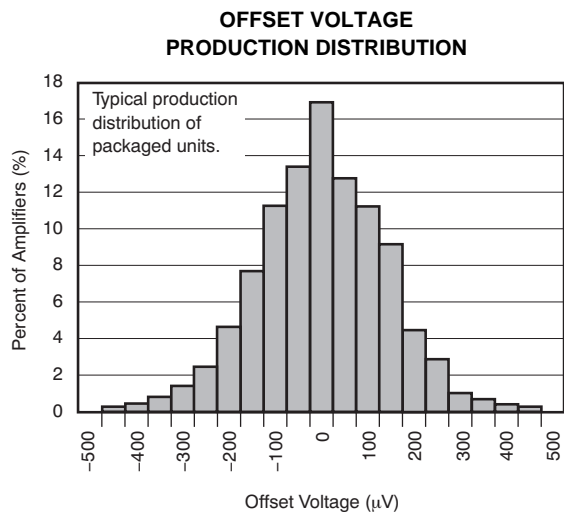


Figure 17.

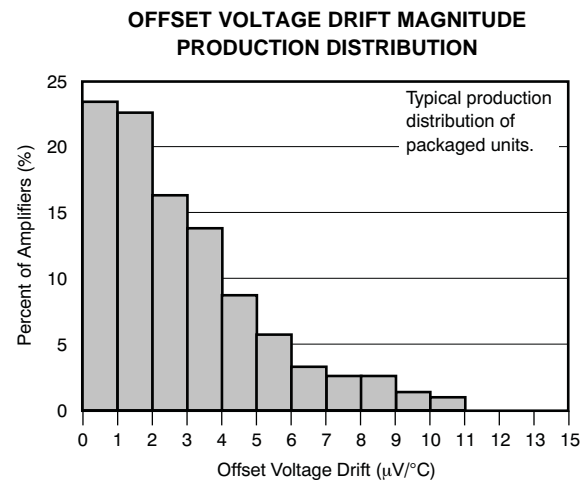


Figure 18.

TYPICAL CHARACTERISTICS (continued)

At $T_A = 25^\circ\text{C}$, $V_S = 5\text{ V}$, and $R_L = 10\text{ k}\Omega$ connected to $V_S/2$ (unless otherwise noted)

SMALL-SIGNAL STEP RESPONSE
 $C_L = 100\text{ pF}$

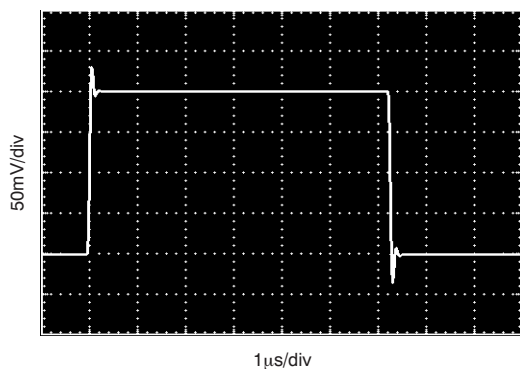


Figure 19.

LARGE-SIGNAL STEP RESPONSE
 $C_L = 100\text{ pF}$

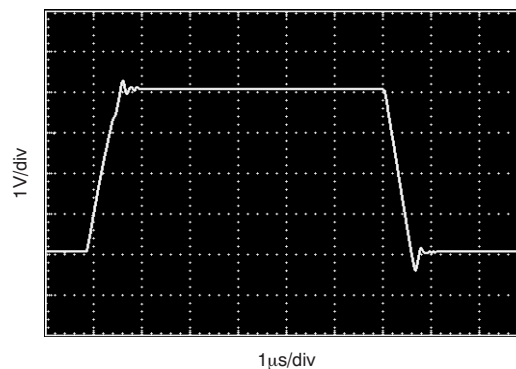


Figure 20.

**SMALL-SIGNAL OVERSHOOT
vs LOAD CAPACITANCE**

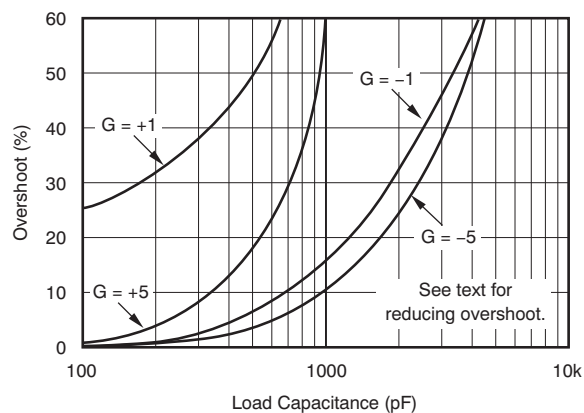


Figure 21.

SETTLING TIME vs CLOSED-LOOP GAIN

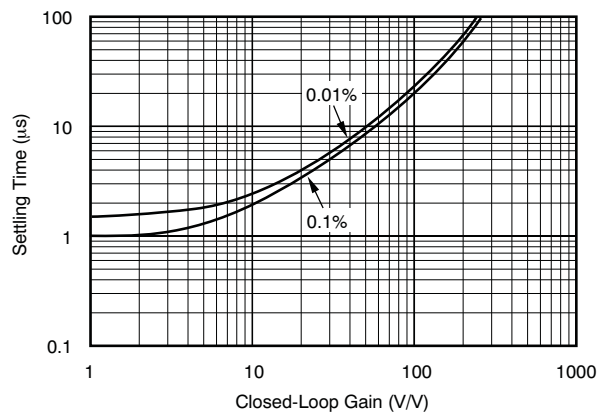


Figure 22.

APPLICATION INFORMATION

The OPA340 is fabricated on a state-of-the-art 0.6-micron CMOS process. It is unity-gain stable and suitable for a wide range of general-purpose applications. Rail-to-rail input/output makes it ideal for driving sampling A/D converters. In addition, excellent ac performance makes it well-suited for audio applications. The class AB output stage is capable of driving 600- Ω loads connected to any point between V_+ and ground.

Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications. Figure 23 shows the input and output waveforms for the OPA340 in unity-gain configuration. Operation is from a single 5-V supply with a 10-k Ω load connected to $V_S/2$. The input is a 5- V_{PP} sinusoid. Output voltage is approximately 4.98 V_{PP} .

Power-supply pins should be bypassed with 0.01- μ F ceramic capacitors.

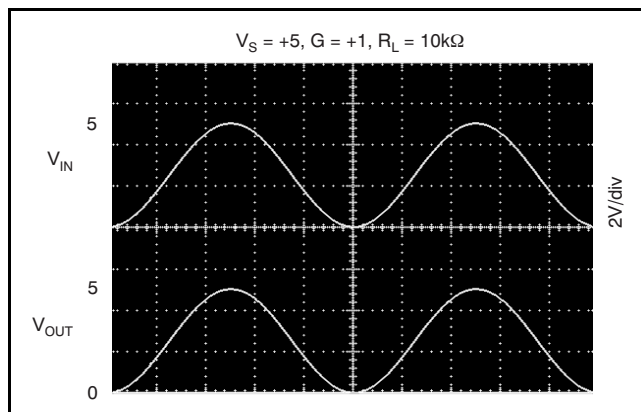


Figure 23. Rail-to-Rail Input and Output

Operating Voltage

The OPA340 is fully specified from 2.7 V to 5 V. Parameters are ensured over the specified supply range—a unique feature of the OPA340 series. In addition, many specifications apply from -55°C to

125°C . Most behavior remains nearly unchanged throughout the full operating voltage range. Parameters that vary significantly with operating voltages or temperature are shown in [Typical Characteristics](#).

Rail-to-Rail Input

The input common-mode voltage range of the OPA340 extends 500 mV beyond the supply rails. This is achieved with a complementary input stage—an N-channel input differential pair in parallel with a P-channel differential pair (as shown in [Figure 24](#)). The N-channel pair is active for input voltages close to the positive rail, typically $(V_+) - 1.3\text{ V}$ to 500 mV above the positive supply, while the P-channel pair is on for inputs from 500 mV below the negative supply to approximately $(V_+) - 1.3\text{ V}$. There is a small transition region, typically $(V_+) - 1.5\text{ V}$ to $(V_+) - 1.1\text{ V}$, in which both pairs are on. This 400-mV transition region can vary $\pm 300\text{ mV}$ with process variation. Thus, the transition region (both stages on) can range from $(V_+) - 1.8\text{ V}$ to $(V_+) - 1.4\text{ V}$ on the low end, up to $(V_+) - 1.2\text{ V}$ to $(V_+) - 0.8\text{ V}$ on the high end.

The OPA340 is laser-trimmed to reduce the offset voltage difference between the N-channel and P-channel input stages, resulting in improved common-mode rejection and a smooth transition between the N-channel pair and the P-channel pair. However, within the 400-mV transition region PSRR, CMRR, offset voltage, offset drift, and THD may be degraded compared to operation outside this region.

A double-folded cascode adds the signal from the two input pairs and presents a differential signal to the class AB output stage. Normally, input bias current is approximately 200 fA; however, input voltages exceeding the power supplies by more than 500 mV can cause excessive current to flow in or out of the input pins. Momentary voltages greater than 500 mV beyond the power supply can be tolerated if the current on the input pins is limited to 10 mA. This is easily accomplished with an input resistor, as shown in [Figure 25](#). Many input signals are inherently current-limited to less than 10 mA; therefore, a limiting resistor is not required.

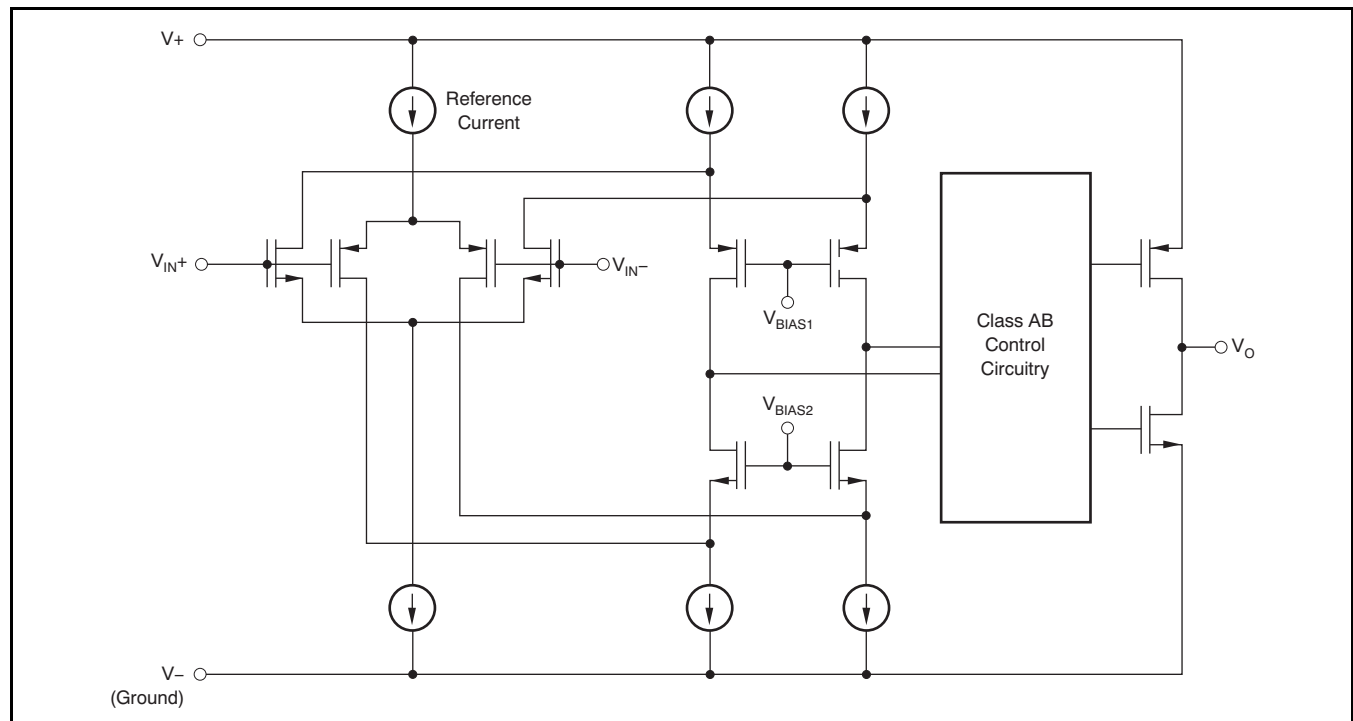


Figure 24. Simplified Schematic

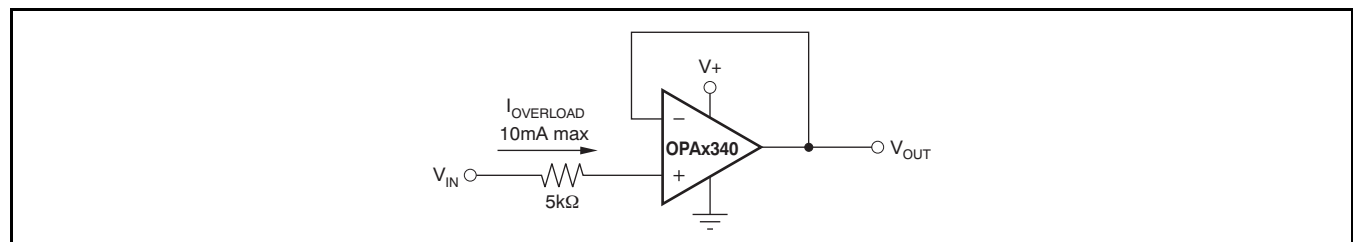


Figure 25. Input Current Protection for Voltages Exceeding the Supply Voltage

RAIL-TO-RAIL OUTPUT

A class AB output stage with common-source transistors is used to achieve rail-to-rail output. For light resistive loads ($> 50 \text{ k}\Omega$), the output voltage is typically a few millivolts from the supply rails. With

moderate resistive loads ($2 \text{ k}\Omega$ to $50 \text{ k}\Omega$), the output can swing to within a few tens of millivolts from the supply rails and maintain high open-loop gain. See the typical characteristic curve [Output Voltage Swing vs Output Current](#).

CAPACITIVE LOAD AND STABILITY

The OPA340 can drive a wide range of capacitive loads. However, all operational amplifiers under certain conditions may become unstable. Op amp configuration, gain, and load value are just a few of the factors to consider when determining stability. An operational amplifier in unity gain configuration is most susceptible to the effects of capacitive load. The capacitive load reacts with the operational amplifier's output resistance, along with any additional load resistance, to create a pole in the small-signal response which degrades the phase margin. In unity gain, OPA340 series operational amplifiers perform well, with a pure capacitive load up to approximately 1000 pF. Increasing gain enhances the amplifier's ability to drive more capacitance. See the typical performance curve [Small-Signal Overshoot vs Capacitive Load](#).

One method of improving capacitive load drive in the unity gain configuration is to insert a 10-Ω to 20-Ω resistor in series with the output, as shown in [Figure 26](#). This significantly reduces ringing with large capacitive loads. However, if there is a resistive load in parallel with the capacitive load, it creates a voltage divider introducing a dc error at the output and slightly reduces output swing. This error may be insignificant. For example, with $R_L = 10\text{ k}\Omega$ and $R_S = 20\text{ }\Omega$, there is only approximately 0.2% error at the output.

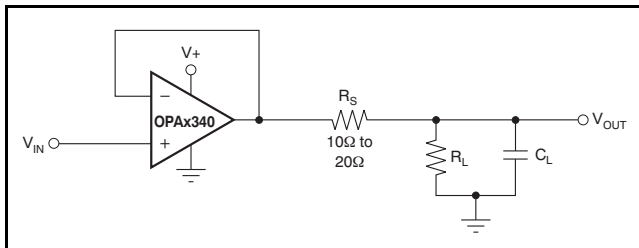


Figure 26. Series Resistor in Unity-Gain Configuration Improves Capacitive Load Drive

DRIVING A/D CONVERTERS

The OPA340 is optimized for driving medium speed (up to 100 kHz) sampling A/D converters. However, it also offers excellent performance for higher speed converters. The OPA340 provides an effective means of buffering the A/D converter's input capacitance and resulting charge injection while providing signal gain. [Figure 27](#) and [Figure 28](#) show the OPA340 driving an [ADS7816](#). The [ADS7816](#) is a 12-bit, micro-power sampling converter in the tiny MSOP-8 package. When used with the miniature package options of the OPA340 series, the combination is ideal for space-limited and low-power applications. For further information consult the [ADS7816 data sheet](#). With the OPA340 in a noninverting configuration, an RC network at the amplifier's output can be used to filter high-frequency noise in the signal (see [Figure 27](#)). In the inverting configuration, filtering may be accomplished with a capacitor across the feedback resistor (see [Figure 28](#)).

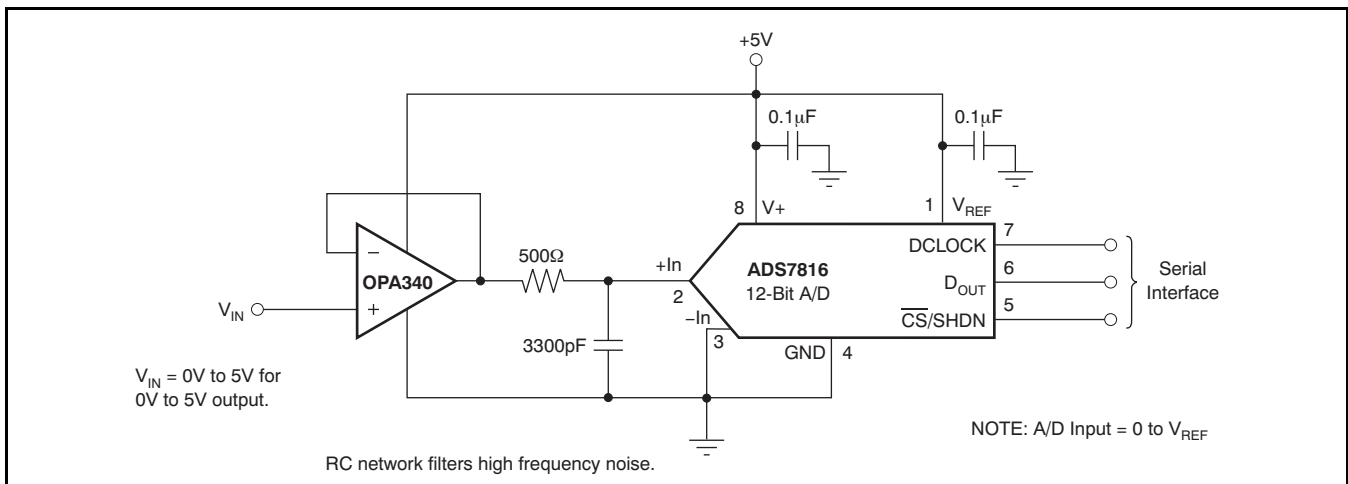
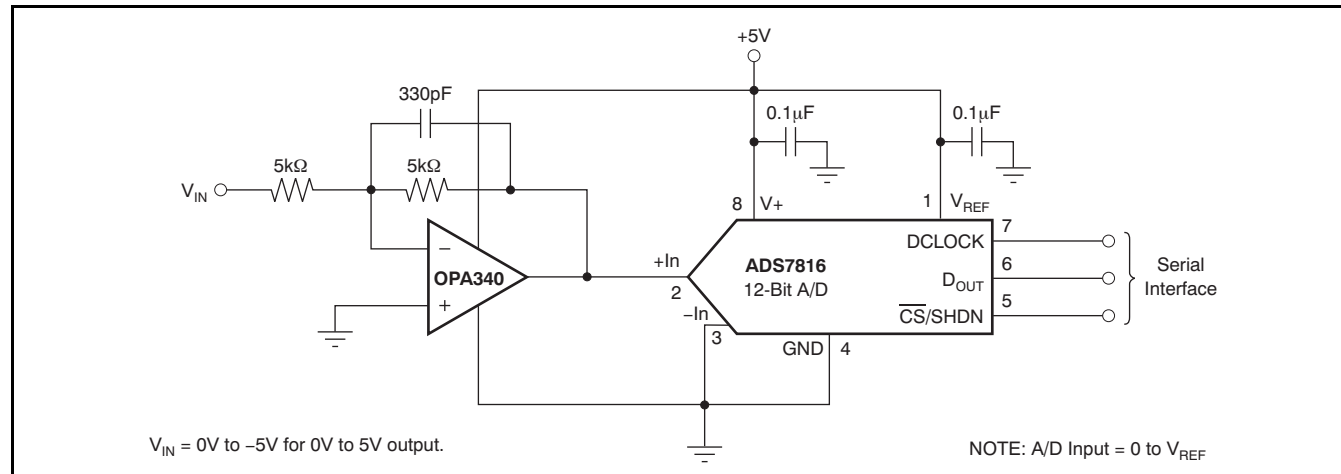
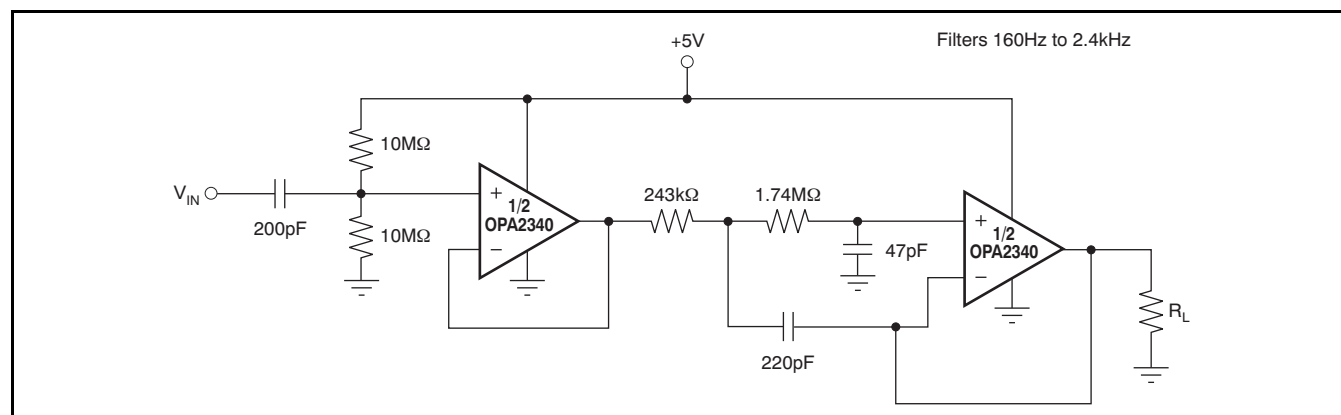


Figure 27. OPA340 in Noninverting Configuration Driving ADS7816**Figure 28. OPA340 in Inverting Configuration Driving ADS7816****Figure 29. Speech Bandpass Filter**

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)
OPA340MDBVTEP	Active	Production	SOT-23 (DBV) 5	250 SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-55 to 125	CVS
V62/08618-01XE	Active	Production	SOT-23 (DBV) 5	250 SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-55 to 125	CVS

⁽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.

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OTHER QUALIFIED VERSIONS OF OPA340-EP :

- Catalog : [OPA340](#)

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
OPA340MDBVTEP	SOT-23	DBV	5	250	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS

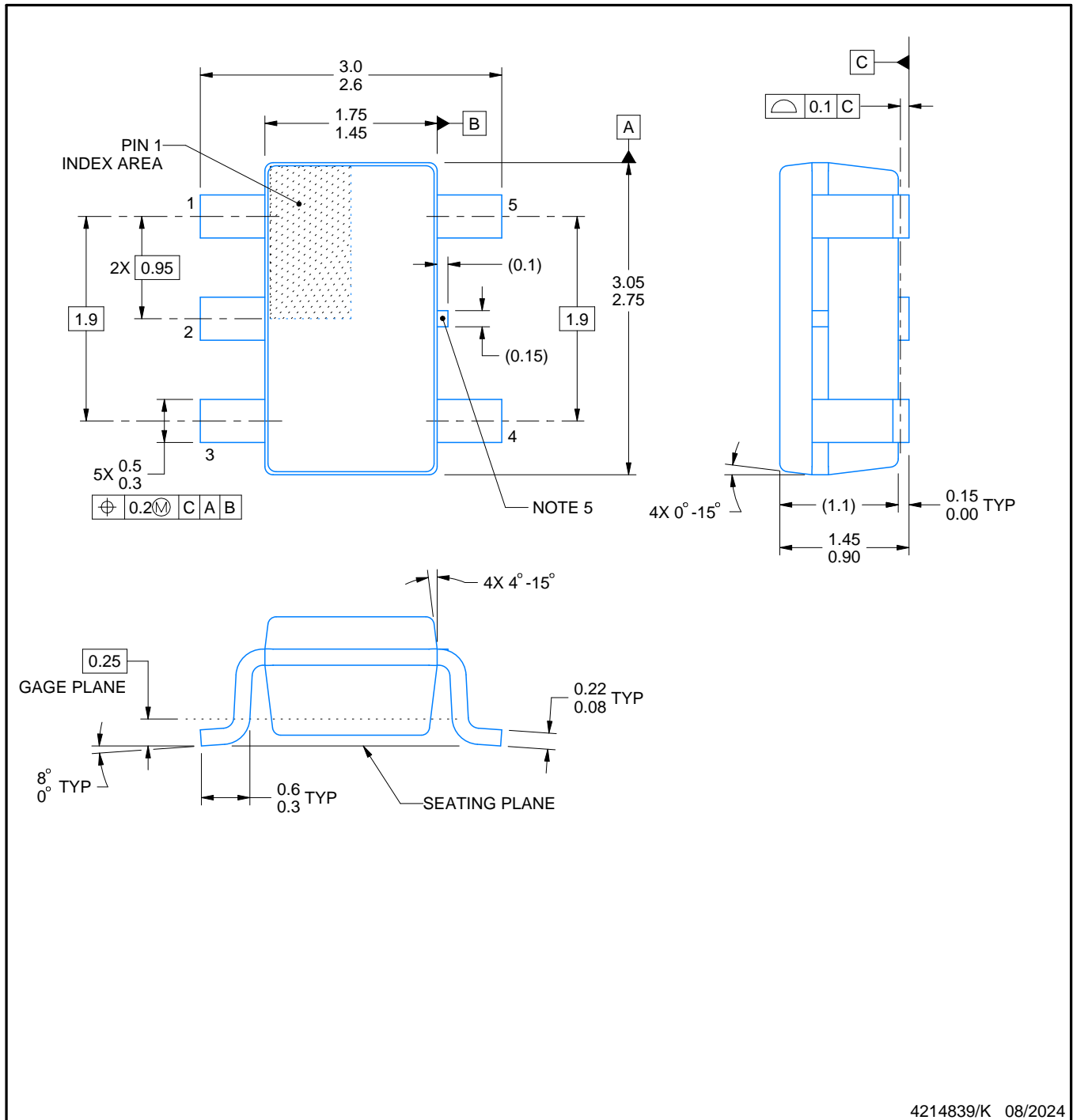


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
OPA340MDBVTEP	SOT-23	DBV	5	250	213.0	191.0	35.0

DBV0005A**PACKAGE OUTLINE****SOT-23 - 1.45 mm max height**

SMALL OUTLINE TRANSISTOR



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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. Reference JEDEC MO-178.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25 mm per side.
5. Support pin may differ or may not be present.

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

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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

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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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