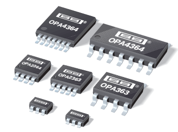
# OPA363
# OPA2363
# OPA364
# OPA2364
# OPA4364



SBOS259B – SEPTEMBER 2002 – REVISED FEBRUARY 2003

# 1.8V, 7MHz, 90dB CMRR, SINGLE-SUPPLY, RAIL-TO-RAIL I/O OPERATIONAL AMPLIFIER

## FEATURES

- **1.8V OPERATION**
- ***Micro*SIZE PACKAGES**
- **BANDWIDTH: 7MHz**
- **CMRR: 90dB (typical)**
- **SLEW RATE: 5V/µs**
- **LOW OFFSET: 500µV (max)**
- **QUIESCENT CURRENT: 750µA/Channel (max)**
- **SHUTDOWN MODE: < 1µA/Channel**

## APPLICATIONS

- **SIGNAL CONDITIONING**
- **DATA ACQUISITION**
- **PROCESS CONTROL**
- **ACTIVE FILTERS**
- **TEST EQUIPMENT**

| | OPA363 | OPA364 | OPA2363 | OPA2364 | OPA4364 |
|---|---|---|---|---|---|
| SOT23-5 | | x | | | |
| SOT23-6 | x | | | | |
| MSOP-8 | | | | x | |
| MSOP-10 | | | x | | |
| SO-8 | x | x | | x | |
| TSSOP-14 | | | | | x |
| SO-14 | | | | | x |

## DESCRIPTION

The OPA363 and OPA364 families are high-performance CMOS operational amplifiers optimized for very low voltage, single-supply operation. These miniature, low-cost amplifiers are designed to operate on single supplies from 1.8V (±0.9V) to 5.5V (±2.75V). Applications include sensor amplification and signal conditioning in battery-powered systems.

The OPA363 and OPA364 families offer excellent CMRR without the crossover associated with traditional complimentary input stages. This results in excellent performance for driving Analog-to-Digital (A/D) converters without degradation of differential linearity and THD. The input common-mode range includes both the negative and positive supplies. The output voltage swing is within 10mV of the rails.

The OPA363 family includes a shutdown mode. Under logic control, the amplifiers can be switched from normal operation to a standby current that is less than 1µA.

The single version is available in the *Micro*SIZE SOT23-5 (SOT23-6 for shutdown) and SO-8. The dual version is available in MSOP-8, MSOP-10, and SO-8 packages. Quad packages are available in TSSOP-14 and SO-14 packages. All versions are specified for operation from –40°C to +125°C.

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.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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## ABSOLUTE MAXIMUM RATINGS(1)

| | |
|---|---|
| Supply Voltage | +5.5V |
| Signal Input Terminals, Voltage(2) | –0.5V to (V+) + 0.5V |
| Current(2) | ±10mA |
| Enable Input | (V–) – 0.5V to 5.5V |
| Output Short-Circuit(3) | Continuous |
| Operating Temperature | –40°C to +150°C |
| Storage Temperature | –65°C to +150°C |
| Junction Temperature | +150°C |
| Lead Temperature (soldering, 10s) | +300°C |

NOTES: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied. (2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current limited to 10mA or less. (3) Short-circuit to ground one amplifier per package.

## ELECTROSTATIC DISCHARGE SENSITIVITY

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.

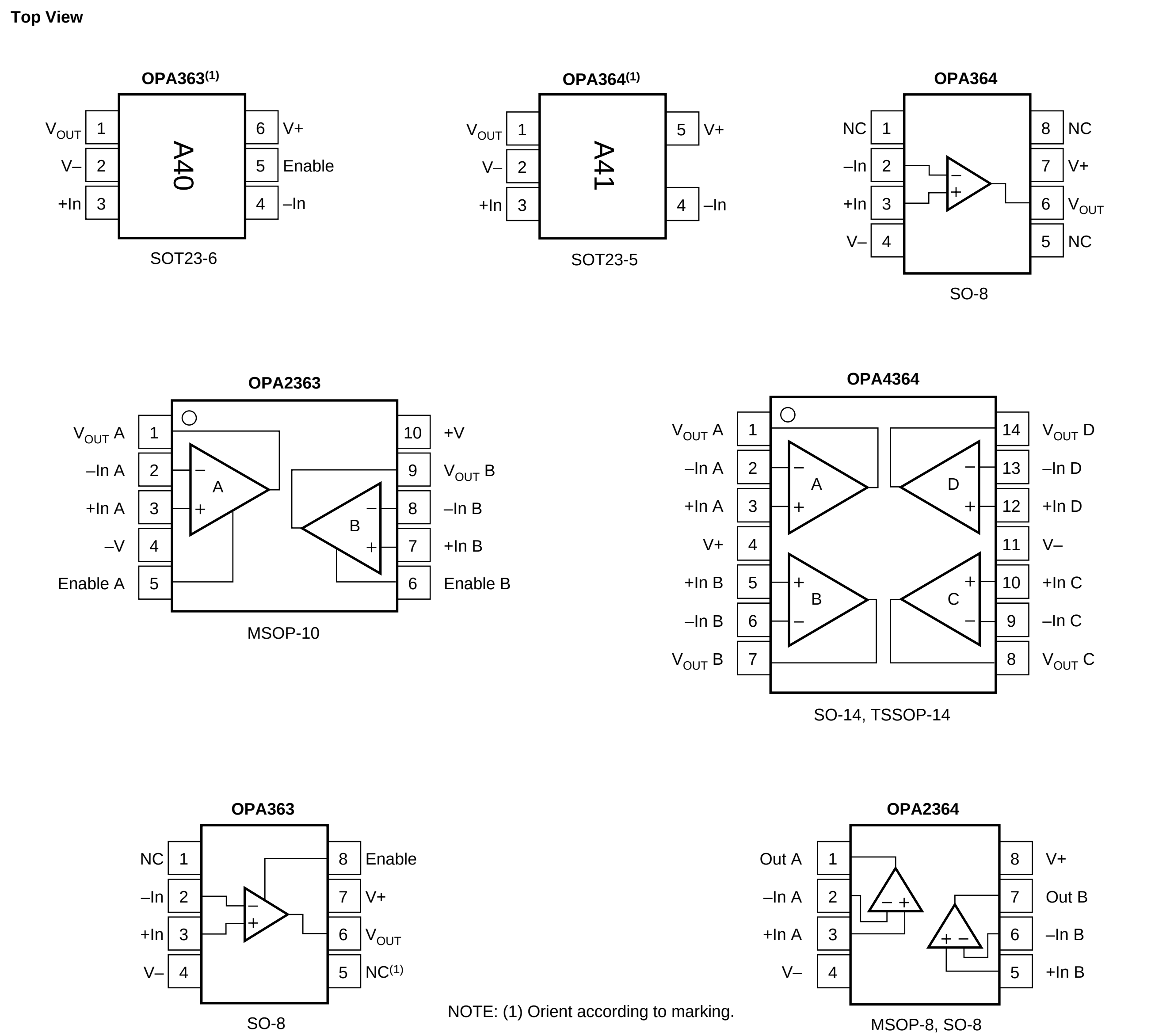
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## PACKAGE/ORDERING INFORMATION

| PRODUCT | PACKAGE-LEAD | PACKAGE DESIGNATOR(1) | SPECIFIED TEMPERATURE RANGE | PACKAGE MARKING | ORDERING NUMBER | TRANSPORT MEDIA, QUANTITY |
|---|---|---|---|---|---|---|
| OPA363I | SOT23-6 | DBV | –40°C to +125°C | A40 | OPA363IDBVT | Tape and Reel, 250 |
| " | " | " | " | " | OPA363IDBVR | Tape and Reel, 3000 |
| OPA363I | SO-8 | D | –40°C to +125°C | OPA363 | OPA363ID | Rails, 100 |
| " | " | " | " | " | OPA363IDR | Tape and Reel, 2500 |
| OPA2363I | MSOP-10 | DGS | –40°C to +125°C | BHK | OPA2363IDGST | Tape and Reel, 250 |
| " | " | " | " | " | OPA2363IDGSR | Tape and Reel, 2500 |
| OPA364I | SOT23-5 | DBV | –40°C to +125°C | A41 | OPA364IDBVT | Tape and Reel, 250 |
| " | " | " | " | " | OPA364IDBVR | Tape and Reel, 3000 |
| OPA364I | SO-8 | D | –40°C to +125°C | OPA364 | OPA364ID | Rails, 100 |
| " | " | " | " | " | OPA364IDR | Tape and Reel, 2500 |
| OPA2364I | MSOP-8 | DGK | –40°C to +125°C | BHL | OPA2364IDGKT | Tape and Reel, 250 |
| " | " | " | " | " | OPA2364IDGKR | Tape and Reel, 2500 |
| OPA2364I | SO-8 | D | –40°C to +125°C | OPA2364 | OPA2364ID | Rails, 100 |
| " | " | " | " | " | OPA2364IDR | Tape and Reel, 2500 |
| OPA363AI | SOT23-6 | DBV | –40°C to +125°C | A40 | OPA363AIDBVT | Tape and Reel, 250 |
| " | " | " | " | " | OPA363AIDBVR | Tape and Reel, 3000 |
| OPA363AI | SO-8 | D | –40°C to +125°C | OPA363A | OPA363AID | Rails, 100 |
| " | " | " | " | " | OPA363AIDR | Tape and Reel, 2500 |
| OPA2363AI | MSOP-10 | DGS | –40°C to +125°C | BHK | OPA2363AIDGST | Tape and Reel, 250 |
| " | " | " | " | " | OPA2363AIDGSR | Tape and Reel, 2500 |
| OPA364AI | SOT23-5 | DBV | –40°C to +125°C | A41 | OPA364AIDBVT | Tape and Reel, 250 |
| " | " | " | " | " | OPA364AIDBVR | Tape and Reel, 3000 |
| OPA364AI | SO-8 | D | –40°C to +125°C | OPA364A | OPA364AID | Rails, 100 |
| " | " | " | " | " | OPA364AIDR | Tape and Reel, 2500 |
| OPA2364AI | SO-8 | D | –40°C to +125°C | OPA2634A | OPA2364AID | Rails, 100 |
| " | " | " | " | " | OPA2364AIDR | Tape and Reel, 2500 |
| OPA2364AI | MSOP-8 | DGK | –40°C to +125°C | BHL | OPA2364AIDGKT | Tape and Reel, 250 |
| " | " | " | " | " | OPA2364AIDGKR | Tape and Reel, 2500 |
| OPA4364AI | SO-14 | D | –40°C to +125°C | OPA4364A | OPA4364AID | Rails, 58 |
| " | " | " | " | " | OPA4364AIDR | Tape and Reel, 2500 |
| OPA4364AI | TSSOP-14 | PW | –40°C to +125°C | OPA4364A | OPA4364AIPWT | Tape and Reel, 250 |
| " | " | " | " | " | OPA4364AIPWR | Tape and Reel, 2500 |

NOTES: (1) For the most current specifications and package information, refer to our web site at www.ti.com.

## PIN CONFIGURATIONS




NOTE: (1) Orient according to marking.

NC = No Internal Connection.

# ELECTRICAL CHARACTERISTICS: $V_S$ = +1.8V to +5.5V

**Boldface** limits apply over the specified temperature range, **$T_A$ = –40°C to +125°C.**

At $T_A$ = +25°C, $R_L$ = 10kΩ connected to $V_S$/2, and $V_{OUT}$ = $V_S$/2, $V_{CM}$ = $V_S$/2, unless otherwise noted.

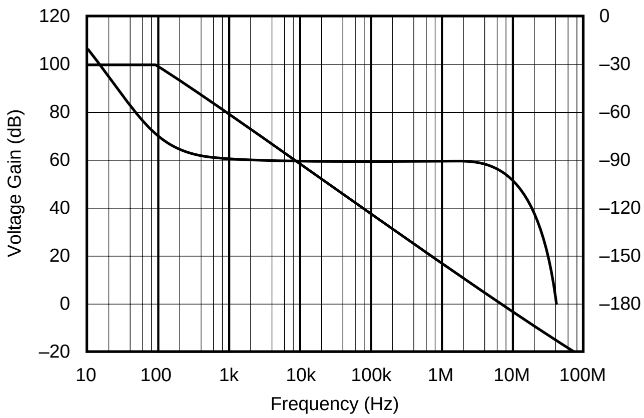
| PARAMETER | | CONDITION | OPAx363, OPAx364 MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **OFFSET VOLTAGE** | | | | | | |
| Input Offset Voltage, OPA363I, OPA364I | $V_{OS}$ | $V_S$ = +5V | | | 500 | µV |
| OPA2363I, OPA2364I | | | | | 900 | µV |
| OPA363AI, OPA364AI, OPA2363AI, OPA2364AI, OPA4364AI | | | | 1 | 2.5 | mV |
| **Drift** | **$dV_{OS}/dT$** | | | **3** | | **µV/°C** |
| **vs Power Supply** | **PSRR** | **$V_S$ = 1.8V to 5.5V, $V_{CM}$ = 0** | | **80** | **330** | **µV/V** |
| Channel Separation, dc | | | | 1 | | µV/V |
| **INPUT BIAS CURRENT** | | | | | | |
| Input Bias Current | $I_B$ | | | ±1 | ±10 | pA |
| **over Temperature** | | | | See Typical Characteristics | | |
| Input Offset Current | $I_{OS}$ | | | ±1 | ±10 | pA |
| **NOISE** | | | | | | |
| Input Voltage Noise, f = 0.1Hz to 10Hz | $e_n$ | | | 10 | | µVp-p |
| Input Voltage Noise Density, f = 10kHz | $e_n$ | | | 17 | | nV/√Hz |
| Input Current Noise Density, f = 10kHz | $i_n$ | | | 0.6 | | fA/√Hz |
| **INPUT VOLTAGE RANGE** | | | | | | |
| Common-Mode Voltage Range | $V_{CM}$ | | (V–) – 0.1 | | (V+) + 0.1 | V |
| **Common-Mode Rejection Ratio** | **CMRR** | **(V–) – 0.1V < $V_{CM}$ < (V+) + 0.1V** | **74** | **90** | | **dB** |
| **INPUT CAPACITANCE** | | | | | | |
| Differential | | | | 2 | | pF |
| Common-Mode | | | | 3 | | pF |
| **OPEN-LOOP GAIN** | | $R_L$ = 10kΩ, 100mV < $V_O$ < (V+) – 100mV | | | | |
| Open-Loop Voltage Gain | $A_{OL}$ | | 94 | 100 | | dB |
| OPA4364AI | | | 90 | | | dB |
| **over Temperature** | | **$V_S$ = +1.8V to +5.5V** | **86** | | | **dB** |
| **FREQUENCY RESPONSE** | | $C_L$ = 100pF | | | | |
| Gain Bandwidth Product | GBW | | | 7 | | MHz |
| Slew Rate | SR | G = +1 | | 5 | | V/µs |
| Settling Time, 0.1% | $t_S$ | $V_S$ = +5V, 4V Step, G = +1 | | 1 | | µs |
| 0.01% | | $V_S$ = +5V, 4V Step, G = +1 | | 1.5 | | µs |
| Overload Recovery Time | | $V_{IN}$ • Gain > $V_S$ | | 0.8 | | µs |
| Total Harmonic Distortion + Noise | THD+N | $V_S$ = +5V, G = +1, f = 20Hz to 20kHz | | 0.002 | | % |
| **OUTPUT** | | | | | | |
| Voltage Output Swing from Rail | | $R_L$ = 10kΩ | | 10 | 20 | mV |
| **over Temperature** | | **$R_L$ = 10kΩ** | | | **20** | **mV** |
| Short-Circuit Current | $I_{SC}$ | | | See Typical Characteristics | | mA |
| Capacitive Load Drive | $C_{LOAD}$ | | | See Typical Characteristics | | |
| **SHUTDOWN (for OPAx363)** | | | | | | |
| $t_{OFF}$ | | | | 1 | | µs |
| $t_{ON}$(1) | | | | 20 | | µs |
| $V_L$ (shutdown) | | | | | (V–) + 0.8 | V |
| $V_H$ (amplifier is active) | | | 0.75 (V+) | | 5.5 | V |
| $I_{QSD}$ | | | | | 0.9 | µA |
| **POWER SUPPLY** | | | | | | |
| Specified Voltage Range | $V_S$ | | 1.8 | | 5.5 | V |
| Operating Voltage Range | | | | 1.8 to 5.5 | | V |
| Quiescent Current (per amplifier) | $I_Q$ | **$V_S$ = +1.8V** | | **650** | **750** | **µA** |
| | | **$V_S$ = +3.6V** | | **850** | **1000** | **µA** |
| | | **$V_S$ = +5.5V** | | **1.1** | **1.4** | **mA** |
| **TEMPERATURE RANGE** | | | | | | |
| Specified Range | | | –40 | | +125 | °C |
| Operating Range | | | –40 | | +150 | °C |
| Storage Range | | | –65 | | +150 | °C |
| Thermal Resistance | $\theta_{JA}$ | | | | | |
| SOT23-5, SOT23-6 | | | | 200 | | °C/W |
| MSOP-8, MSOP-10, SO-8 | | | | 150 | | °C/W |
| TSSOP-14, SO-14 | | | | 100 | | °C/W |

NOTE: (1) Part is considered enabled when input offset voltage returns to specified range.

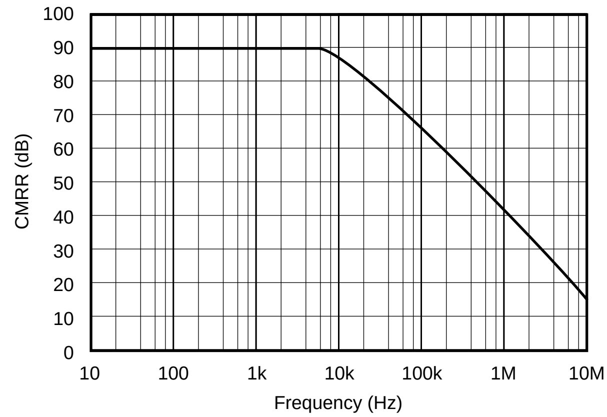
# TYPICAL CHARACTERISTICS

At $T_{CASE}$ = +25°C, $R_L$ = 10kΩ, and connected to $V_S/2$, $V_{OUT} = V_S/2$, $V_{CM} = V_S/2$, unless otherwise noted.

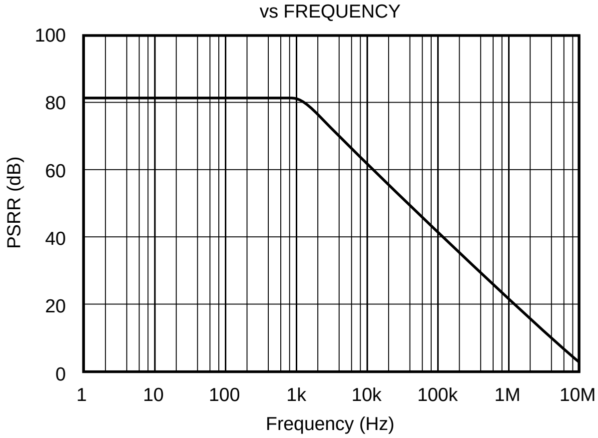
OPEN-LOOP GAIN/PHASE vs FREQUENCY



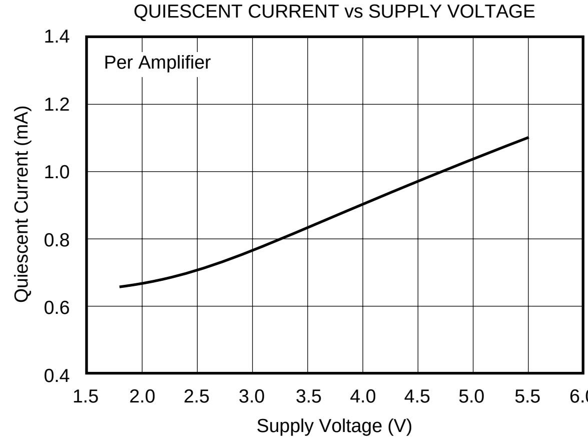

COMMON-MODE REJECTION RATIO vs FREQUENCY



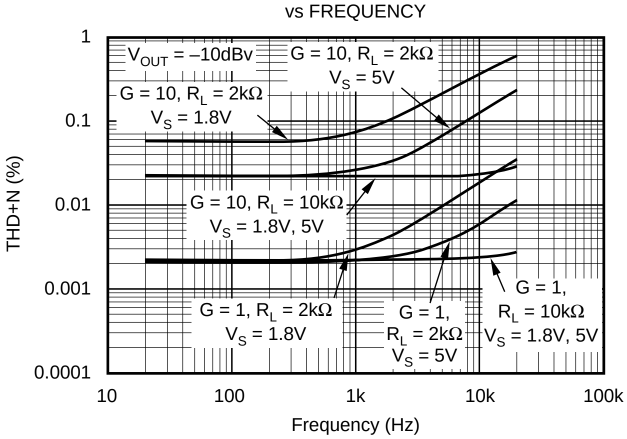

POWER-SUPPLY REJECTION RATIO vs FREQUENCY



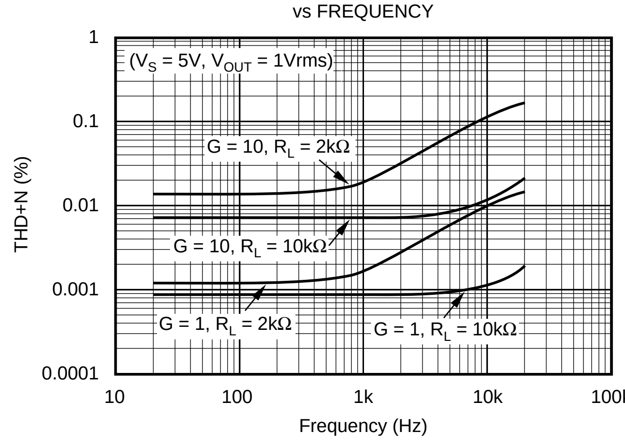

QUIESCENT CURRENT vs SUPPLY VOLTAGE




TOTAL HARMONIC DISTORTION + NOISE vs FREQUENCY

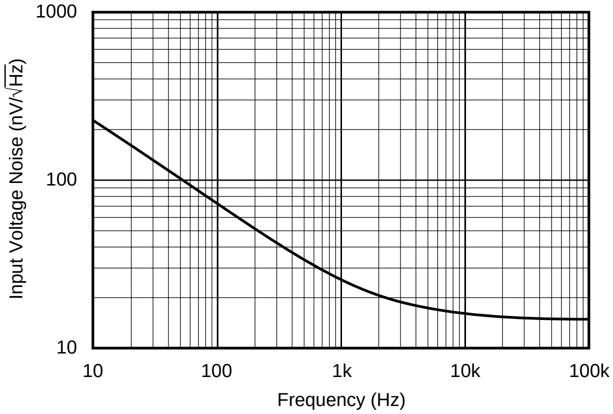



TOTAL HARMONIC DISTORTION + NOISE vs FREQUENCY

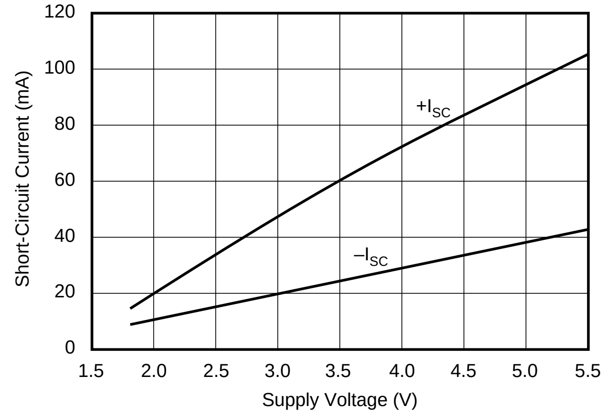


At $T_{CASE}$ = +25°C, $R_L$ = 10kΩ, and connected to $V_S/2$, $V_{OUT} = V_S/2$, $V_{CM} = V_S/2$, unless otherwise noted.

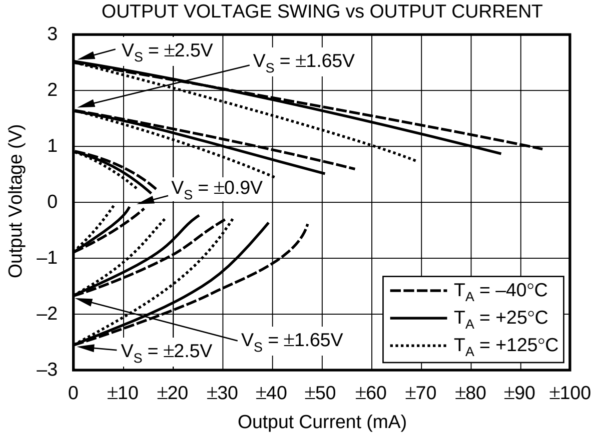
INPUT VOLTAGE NOISE SPECTRAL DENSITY
vs FREQUENCY



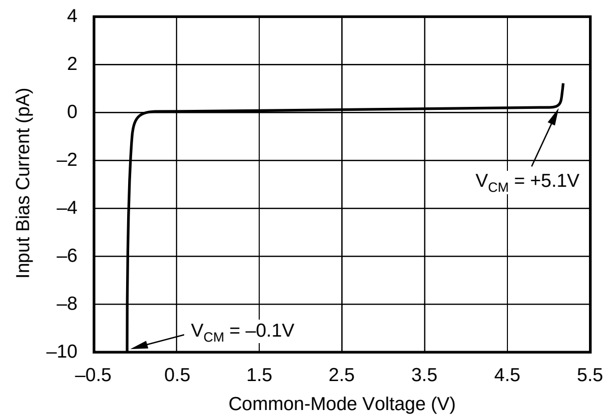

SHORT-CIRCUIT CURRENT vs SUPPLY VOLTAGE



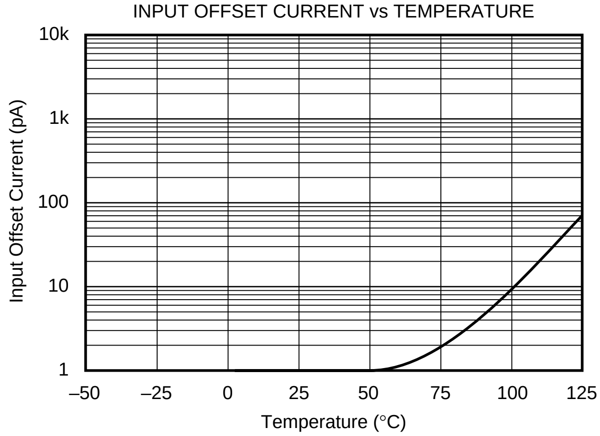

OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



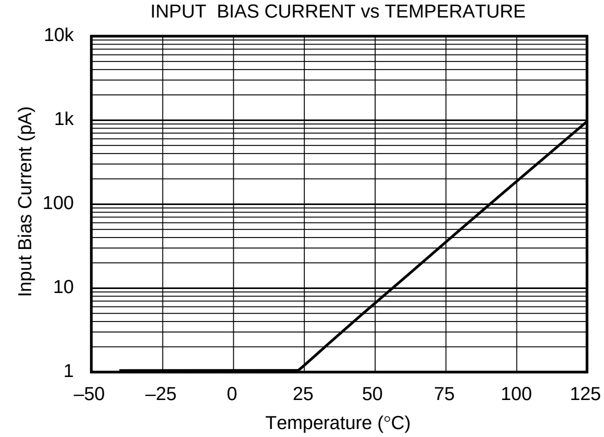

INPUT BIAS CURRENT
vs INPUT COMMON-MODE VOLTAGE




INPUT OFFSET CURRENT vs TEMPERATURE

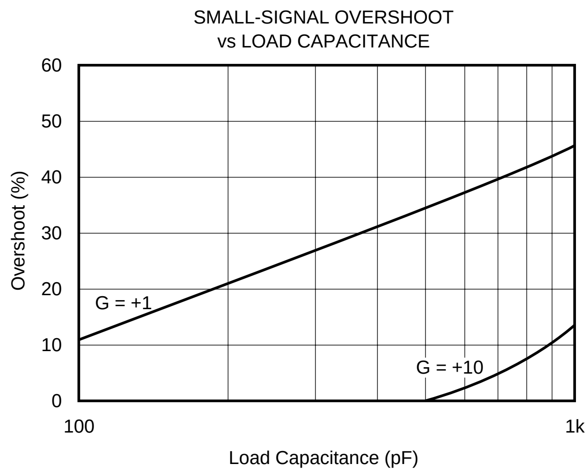


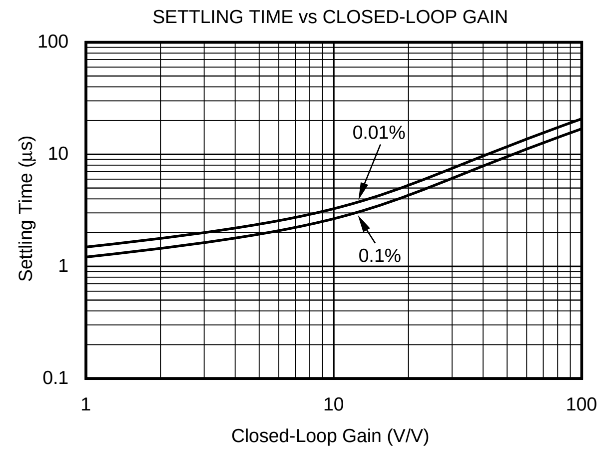

INPUT BIAS CURRENT vs TEMPERATURE

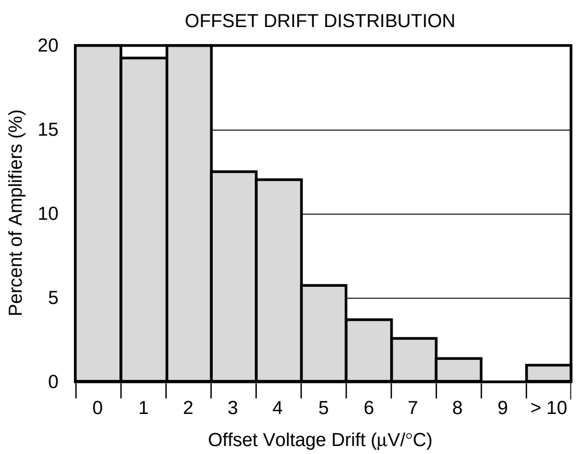


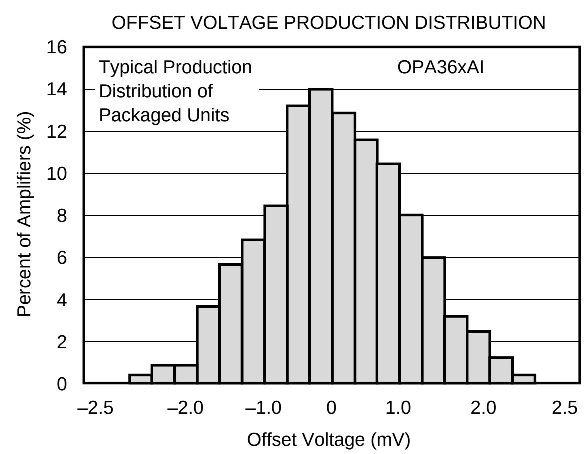
# TYPICAL CHARACTERISTICS (Cont.)

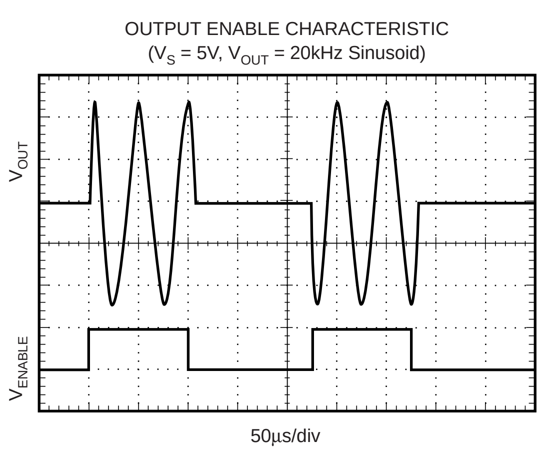
At $T_{CASE}$ = +25°C, $R_L$ = 10kΩ, and connected to $V_S/2$, $V_{OUT} = V_S/2$, $V_{CM} = V_S/2$, unless otherwise noted.

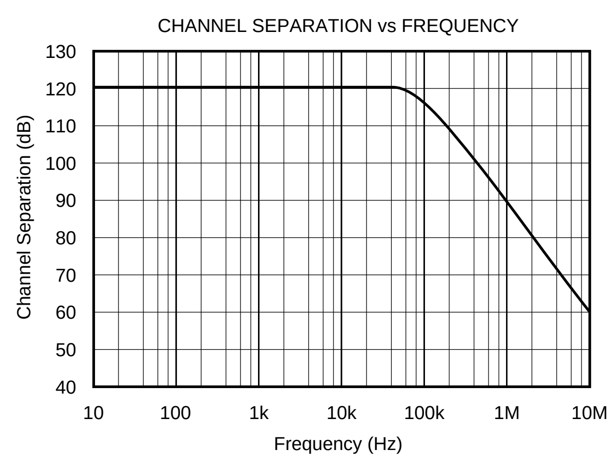


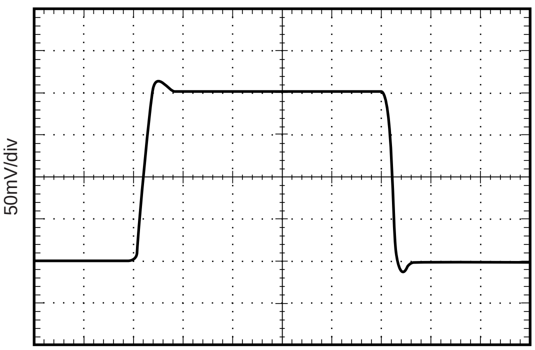



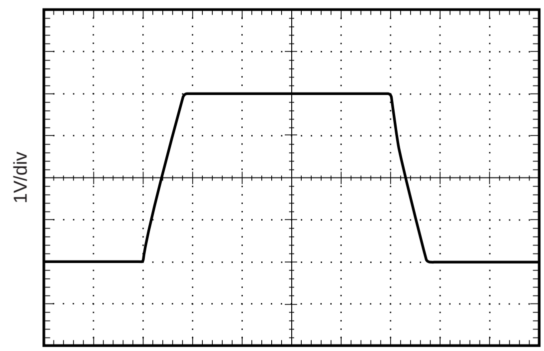



## TYPICAL CHARACTERISTICS (Cont.)

At $T_{CASE}$ = +25°C, $R_L$ = 10kΩ, and connected to $V_S/2$, $V_{OUT} = V_S/2$, $V_{CM} = V_S/2$, unless otherwise noted.




# APPLICATIONS INFORMATION

The OPA363 and OPA364 series op amps are rail-to-rail operational amplifiers with excellent CMRR, low noise, low offset, and wide bandwidth on supply voltages as low as ±0.9V. The OPA363 features an additional pin for shutdown/enable function. These families do not exhibit phase reversal and are unity-gain stable. Specified over the industrial temperature range of –40°C to +125°C, the OPA363 and OPA364 families offer precision performance for a wide range of applications.

### RAIL-TO-RAIL INPUT

The OPA363 and OPA364 feature excellent rail-to-rail operation, with supply voltages as low as ±0.9V. The input common-mode voltage range of the OPA363 and OPA364 family extends 100mV beyond supply rails. The unique input topology of the OPA363 and OPA364 eliminates the input offset transition region typical of most rail-to-rail complimentary stage operational amplifiers, allowing the OPA363 and OPA364 to provide superior common-mode performance over the entire common-mode input range, as seen in Figure 1. This feature prevents degradation of the differential linearity error and THD when driving A/D converters. A simplified schematic of the OPA363 and OPA364 is shown in Figure 2.

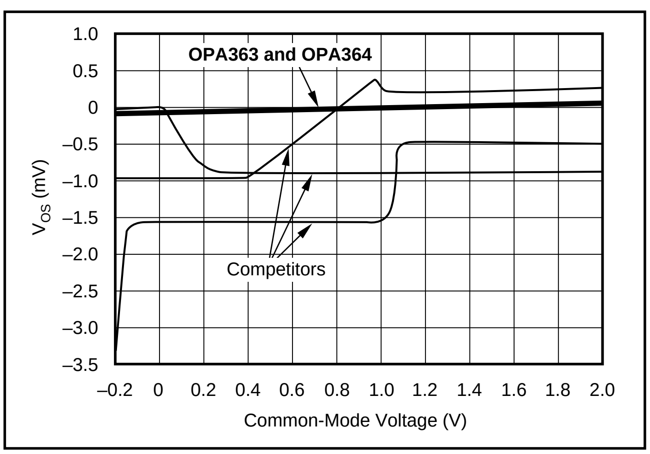



FIGURE 1. OPA363 and OPA364 have Linear Offset Over Entire Common-Mode Range.

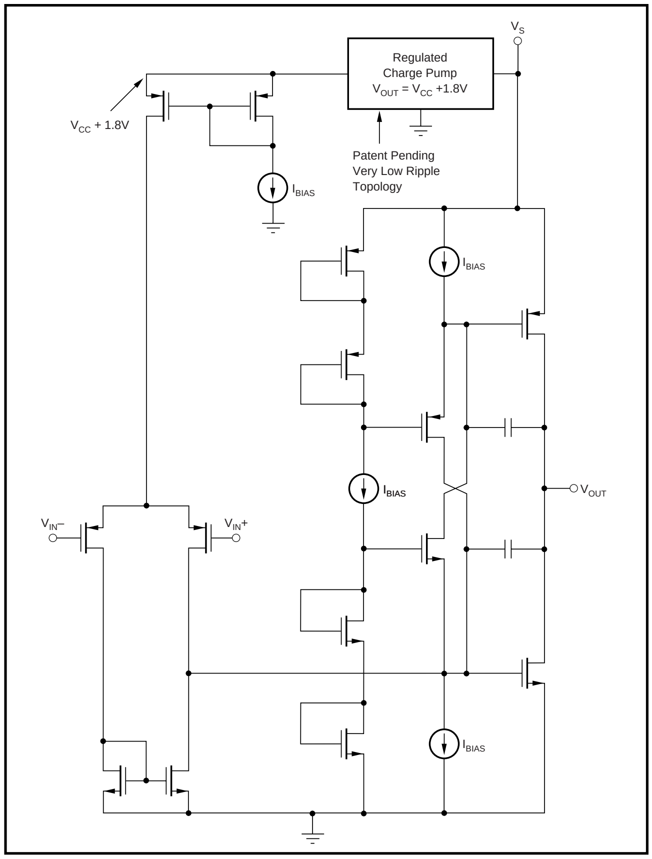



FIGURE 2. Simplified Schematic.

### OPERATING VOLTAGE

The OPA363 and OPA364 series op amp parameters are fully specified from +1.8V to +5.5V. Single 0.1µF bypass capacitors should be placed across supply pins and as close to the part as possible. Supply voltages higher than 5.5V (absolute maximum) may cause permanent damage to the amplifier. Many specifications apply from –40°C to +125°C. Parameters that vary significantly with operating voltages or temperature are shown in the Typical Characteristics.

## ENABLE FUNCTION

The shutdown (enable) function of the OPA363 is referenced to the negative supply voltage of the operational amplifier. A logic level HIGH enables the op amp. A valid logic HIGH is defined as voltage > 75% of the positive supply applied to the enable pin. The valid logic HIGH signal can be as much as 5.5V above the negative supply, independent of the positive supply voltage. A valid logic LOW is defined as < 0.8V above the negative supply pin. If dual or split power supplies are used, care should be taken to ensure logic input signals are properly referred to the negative supply voltage. This pin should be connected to a valid high or low voltage or driven, not left open circuit.

The logic input is a high-impedance CMOS input. Dual op amps are provided separate logic inputs. For battery-operated applications, this feature may be used to greatly reduce the average current and extend battery life. The enable time is 20µs; disable time is 1µs. When disabled, the output assumes a high-impedance state. This allows the OPA363 to be operated as a "gated" amplifier, or to have its output multiplexed onto a common analog output bus.

## CAPACITIVE LOAD

The OPA363 and OPA364 series op amps can drive a wide range of capacitive loads. However, all op amps 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 op amp in unity-gain configuration is the most susceptible to the effects of capacitive load. The capacitive load reacts with the output resistance of the op amp to create a pole in the small-signal response, which degrades the phase margin.

In unity gain, the OPA363 and OPA364 series op amps perform well with a pure capacitive load up to approximately 1000pF. The ESR (Equivalent Series Resistance) of the loading capacitor may be sufficient to allow the OPA363 and OPA364 to directly drive very large capacitive loads (> 1µF). Increasing gain enhances the amplifier's ability to drive more capacitance. See the typical characteristic "Small-Signal Overshoot vs Capacitive Load."

One method of improving capacitive load drive in the unity-gain configuration is to insert a 10Ω to 20Ω resistor in series with the output, as shown in Figure 3. 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 instance, with $R_L$ = 10kΩ and $R_S$ = 20Ω, there is only about a 0.2% error at the output.

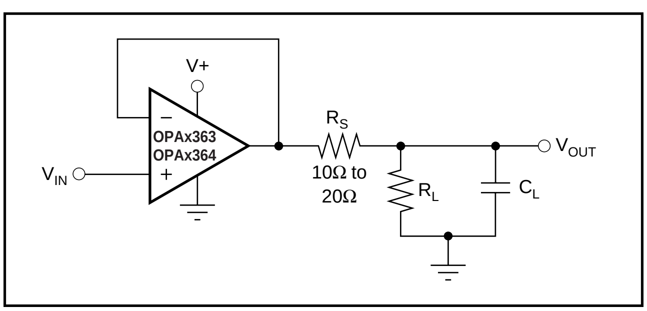



FIGURE 3. Improving Capacitive Load Drive.

## INPUT AND ESD PROTECTION

All OPA363 and OPA364 pins are static protected with internal ESD protection diodes tied to the supplies. These diodes will provide overdrive protection if the current is externally limited to 10mA, as stated in the absolute maximum ratings and shown in Figure 4.

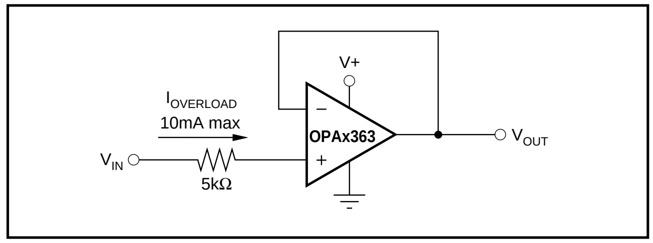



FIGURE 4. Input Current Protection.

## ACHIEVING OUTPUT SWING TO THE OP AMP'S NEGATIVE RAIL

Some applications require an accurate output voltage swing from 0V to a positive full-scale voltage. A good single supply op amp may be able to swing within a few mV of single supply ground, but as the output is driven toward 0V, the output stage of the amplifier will prevent the output from reaching the negative supply rail of the amplifier.

The output of the OPA363 or OPA364 can be made to swing to ground, or slightly below, on a single supply power source. To do so requires use of another resistor and an additional, more negative power supply than the op amp's negative supply. A pulldown resistor may be connected between the output and the additional negative supply to pull the output down below the value that the output would otherwise achieve as shown in Figure 5.

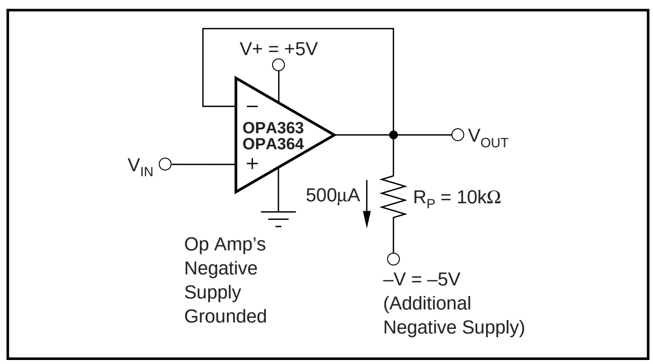



FIGURE 5. OPA363 and OPA364 Swing to Ground.

This technique will not work with all op amps. The output stage of the OPA363 and OPA364 allows the output voltage to be pulled below that of most op amps, if approximately 500µA is maintained through the output stage. To calculate the appropriate value load resistor and negative supply, $R_L$ = –V/500µA. The OPA363 and OPA364 have been characterized to perform well under the described conditions, maintaining excellent accuracy down to 0V and as low as –10mV. Limiting and nonlinearity occur below –10mV, with linearity returning as the output is again driven above –10mV.

## BUFFERED REFERENCE VOLTAGE

Many single-supply applications require a mid-supply reference voltage. The OPA363 and OPA364 offer excellent capacitive load drive capability, and can be configured to provide a 0.9V reference voltage, as can be seen in Figure 6. For appropriate loading considerations, see the "Capacitive Load" section.

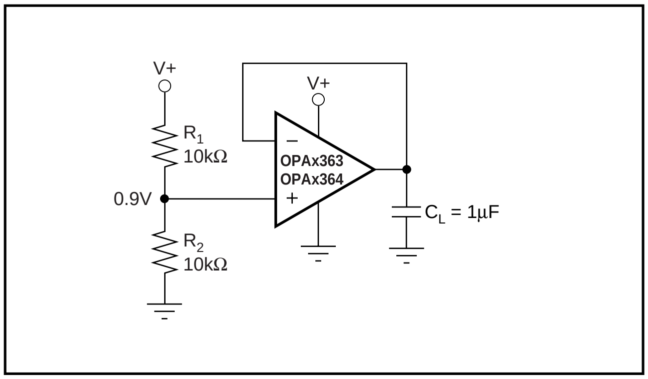



FIGURE 6. The OPA363 and OPA364 Provide a Stable Reference Voltage.

## DIRECTLY DRIVING THE ADS8324 AND THE MSP430

The OPA363 and OPA364 series op amps are optimized for driving medium speed (up to 100kHz) sampling A/D converters. However, they also offer excellent performance for higher speed converters. The no crossover input stage of the OPA363 and OPA364 directly drive A/D converters without degradation of differential linearity and THD. They provide an effective means of buffering the A/D converters input capacitance and resulting charge injection while providing signal gain. Figure 7 and Figure 8 show the OPA363 and OPA364 configured to drive the ADS8324 and the 12-bit A/D converter on the MSP430.

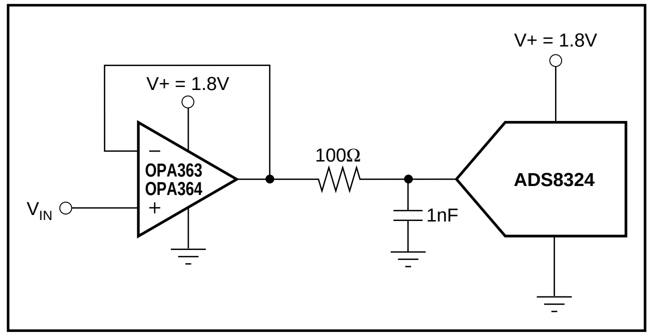



FIGURE 7. The OPA363 and OPA364 Directly Drive the ADS8324.

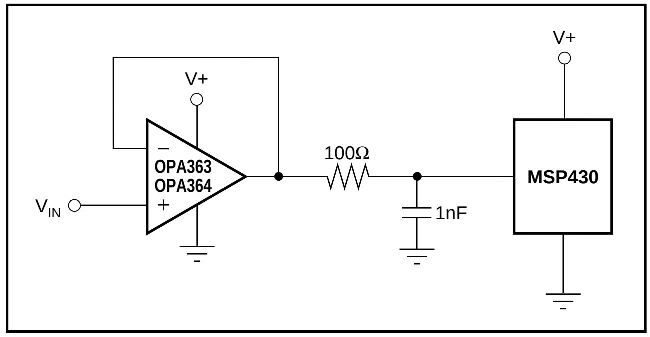



FIGURE 8. Driving the 12-Bit A/D Converter on the MSP430.

## AUDIO APPLICATIONS

The OPA363 and OPA364 op amp family has linear offset voltage over the entire input common-mode range. Combined with low-noise, this feature makes the OPA363 and OPA364 suitable for audio applications. Single supply 1.8V operation allows the OPA2363 and OPA2364 to be optimal candidates for dual stereo-headphone drivers and microphone pre-amplifiers in portable stereo equipment, see Figures 9 and 10.

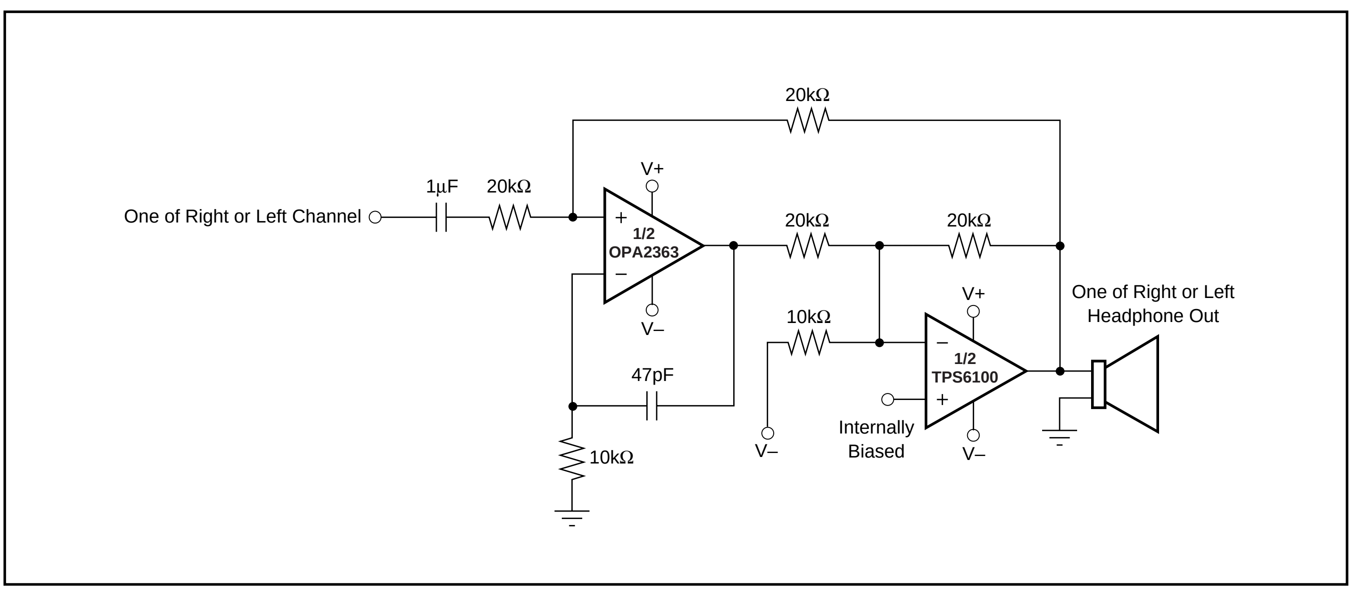



FIGURE 9. OPA2363 Configured as Half of a Dual Stereo Headphone Driver.

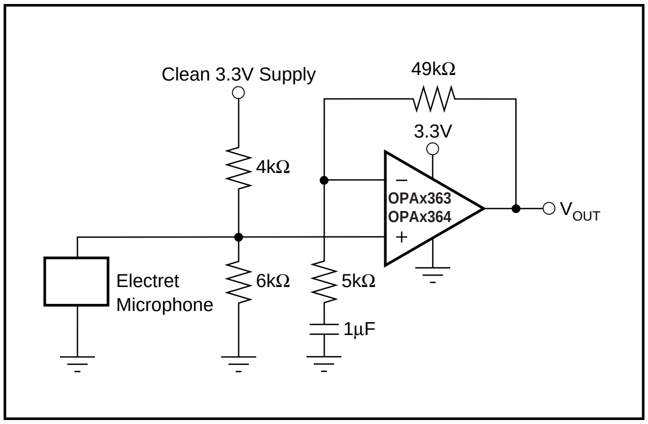



FIGURE 10. Microphone Preamplifier.

## ACTIVE FILTERING

Low harmonic distortion and noise specifications plus high gain and slew rate make the OPA363 and OPA364 optimal candidates for active filtering. Figure 11 shows the OPA2363 configured as a low-distortion, 3rd-order GIC (General Immittance Converter) filter. Figure 12 shows the implementation of a Sallen-Key, 3-pole, low-pass Bessel filter.

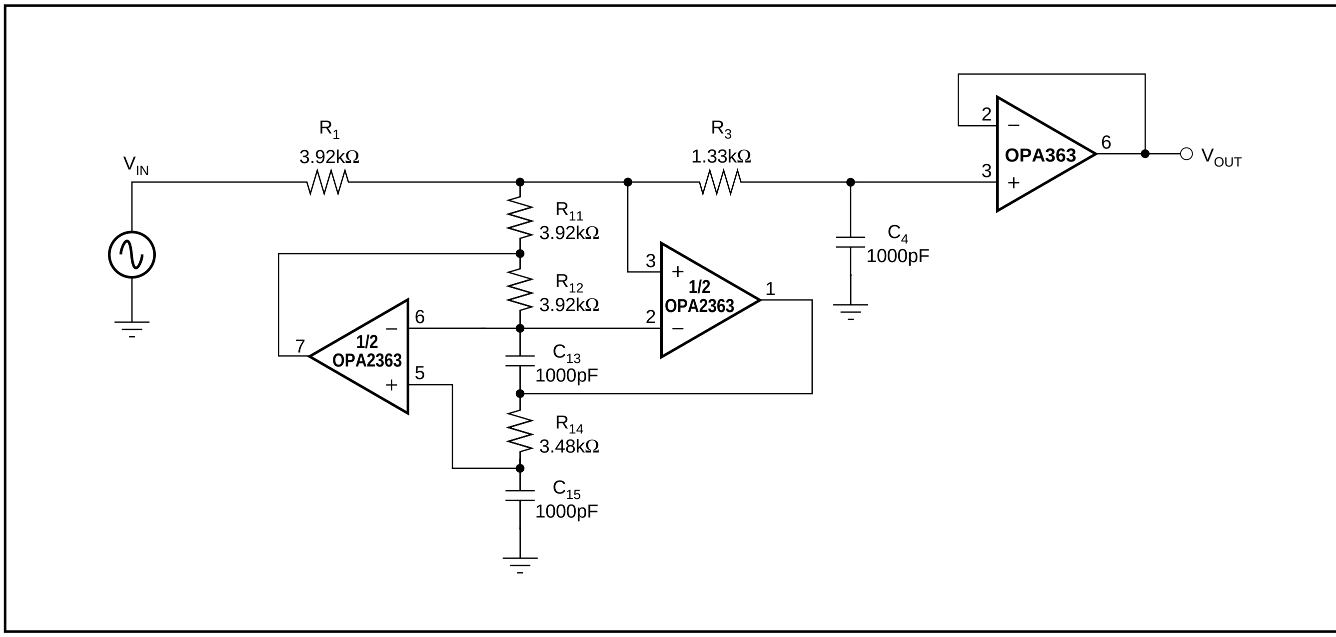



FIGURE 11. The OPA2363 as a 3rd-Order, 40kHz, Low-Pass GIC Filter.

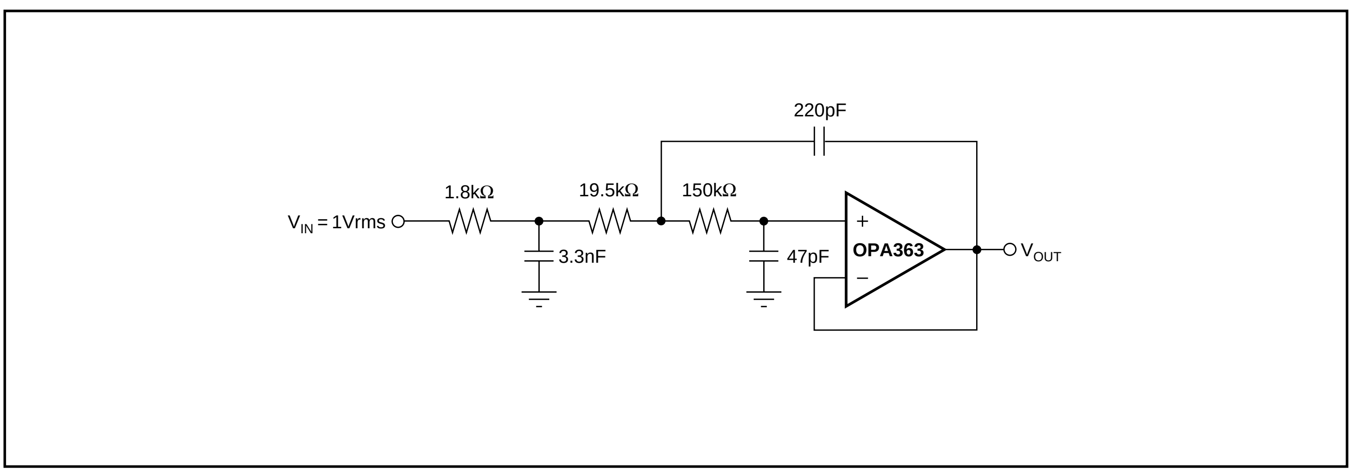
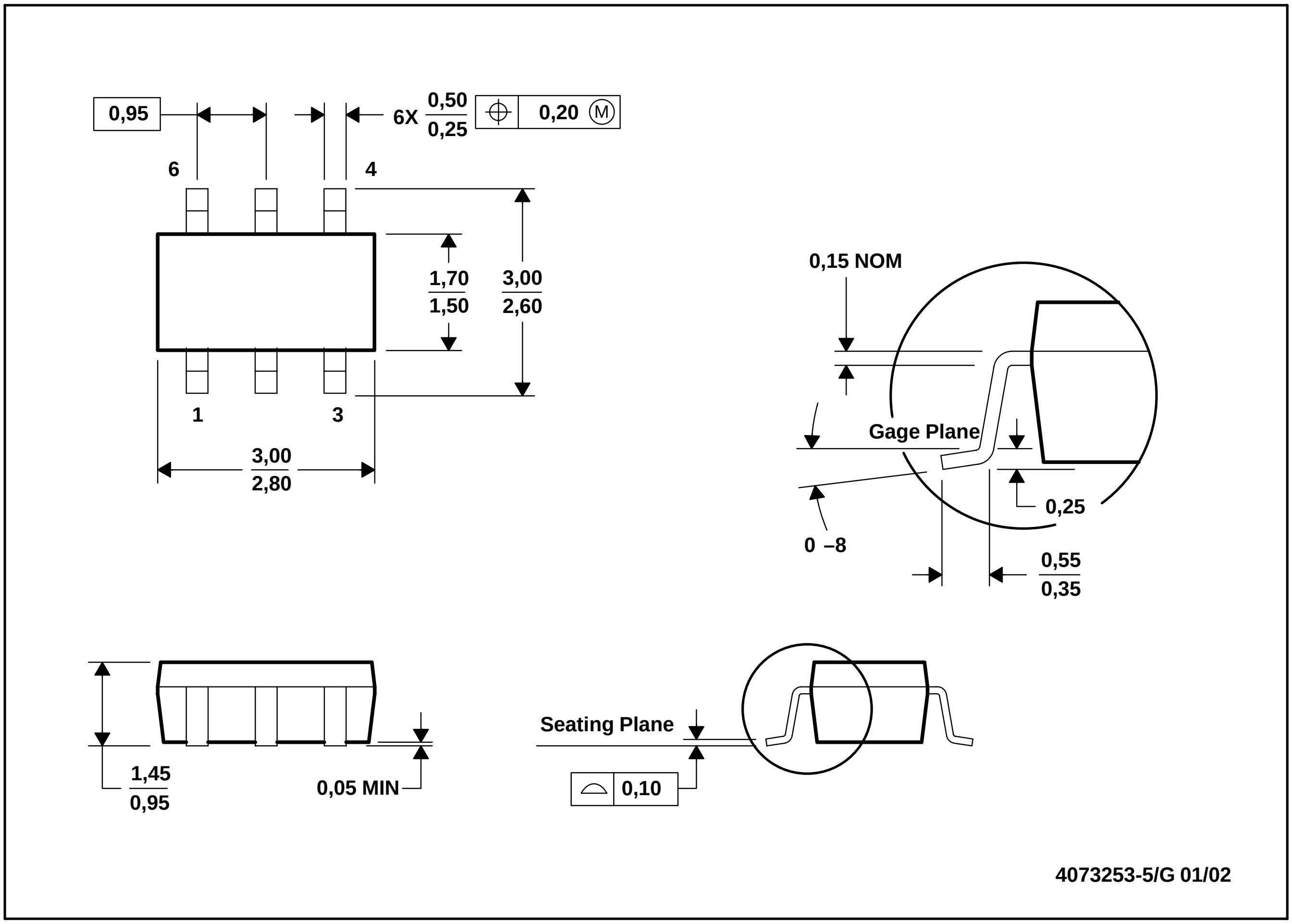



FIGURE 12. The OPA363 or OPA364 Configured as a 3-Pole, 20kHz, Sallen-Key Filter.

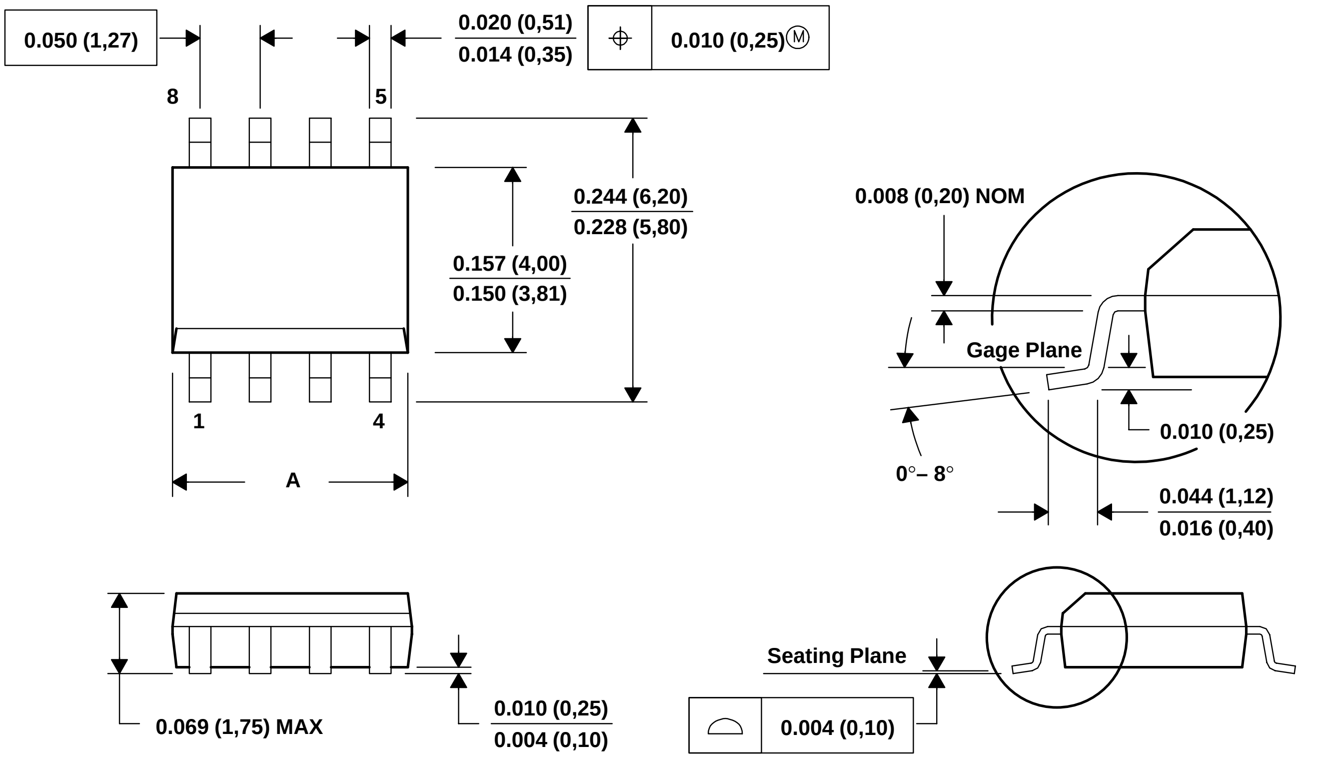
## DBV (R-PDSO-G6) PLASTIC SMALL-OUTLINE




NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.
D. Leads 1, 2, 3 may be wider than leads 4, 5, 6 for package orientation.

**D (R-PDSO-G**)** **PLASTIC SMALL-OUTLINE PACKAGE**

**8 PINS SHOWN**

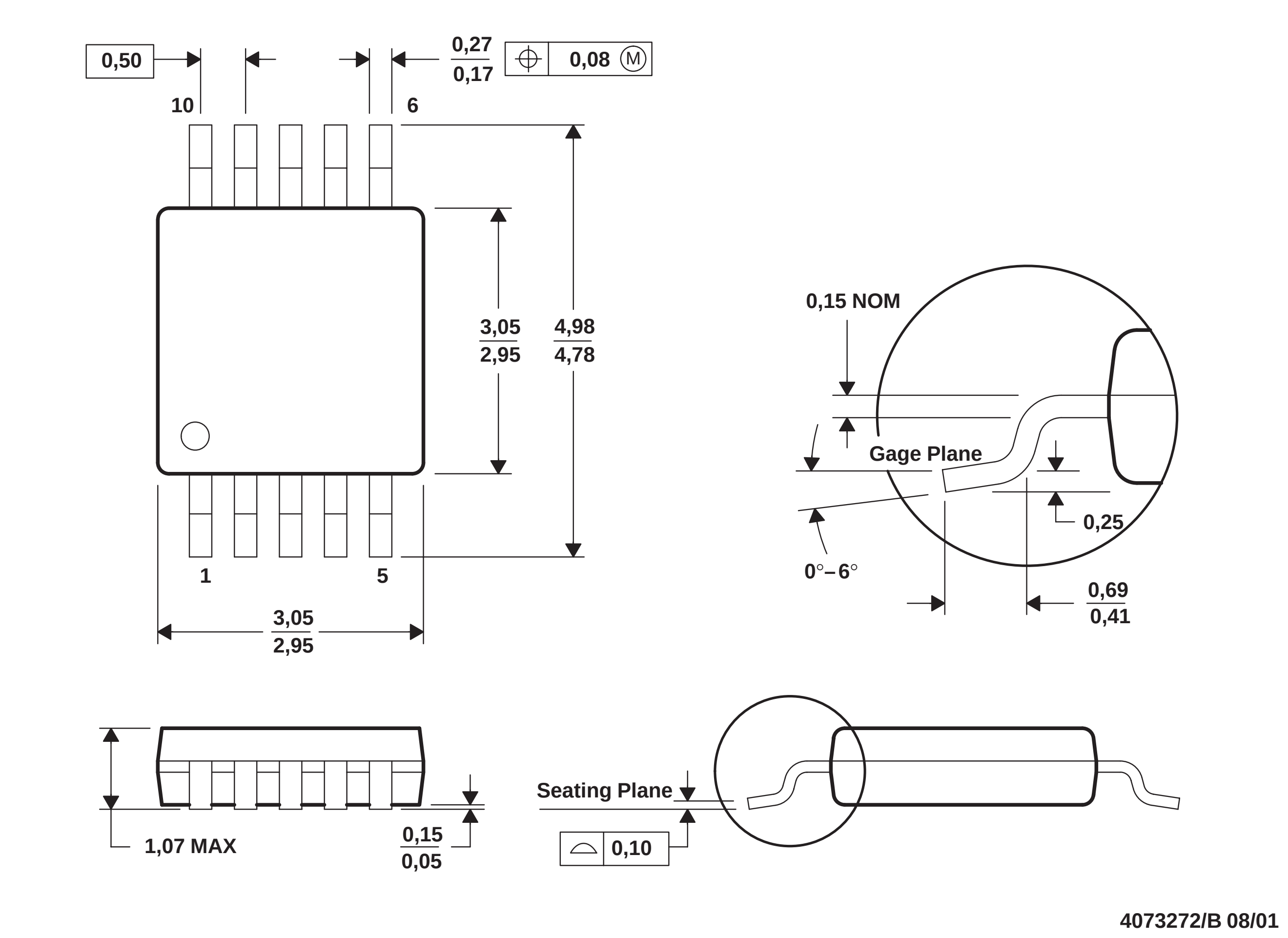



| PINS ** / DIM | 8 | 14 | 16 |
|---|---|---|---|
| A MAX | 0.197 (5,00) | 0.344 (8,75) | 0.394 (10,00) |
| A MIN | 0.189 (4,80) | 0.337 (8,55) | 0.386 (9,80) |

4040047/E 09/01

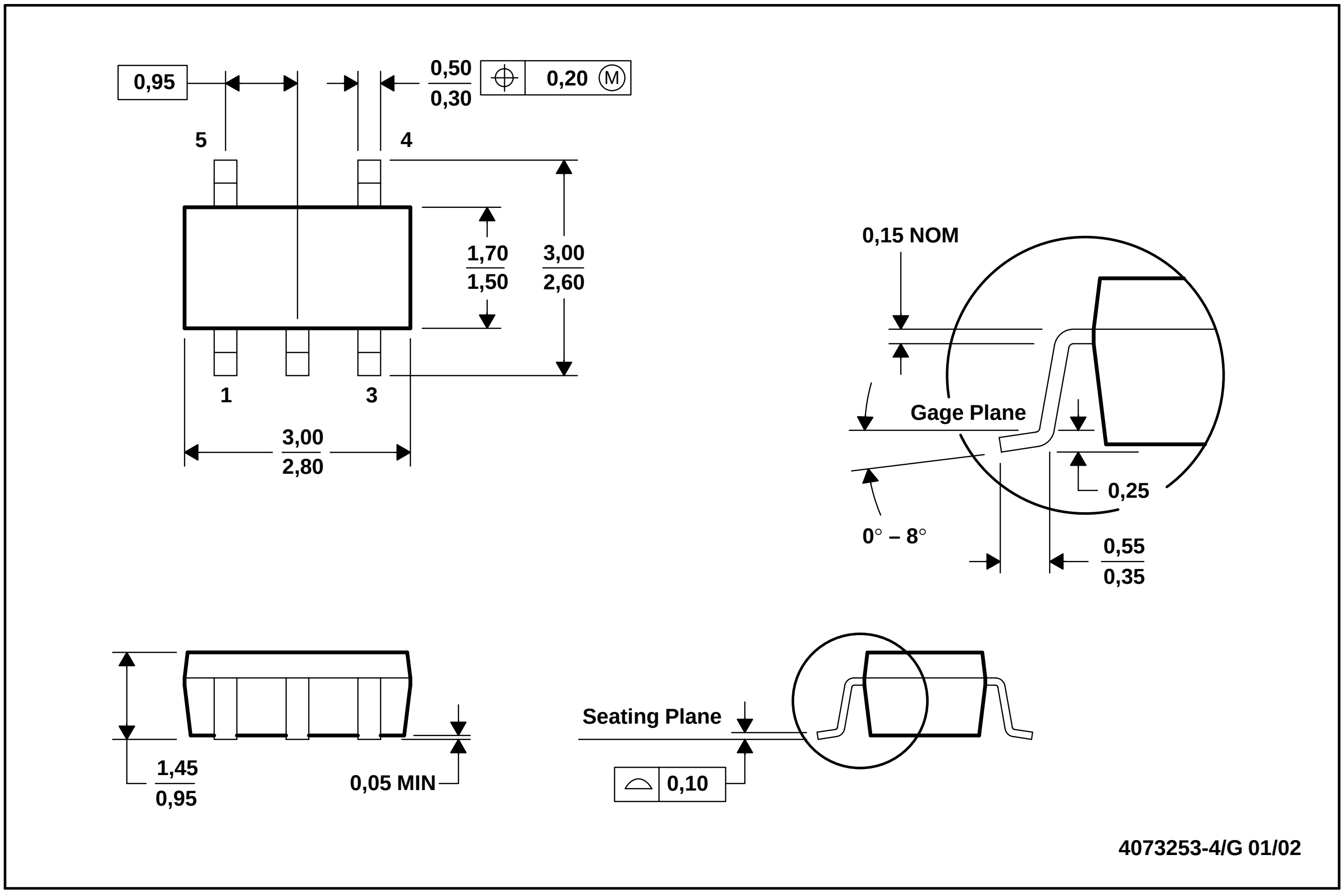
NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
D. Falls within JEDEC MS-012

**DGS (S-PDSO-G10)** **PLASTIC SMALL-OUTLINE PACKAGE**



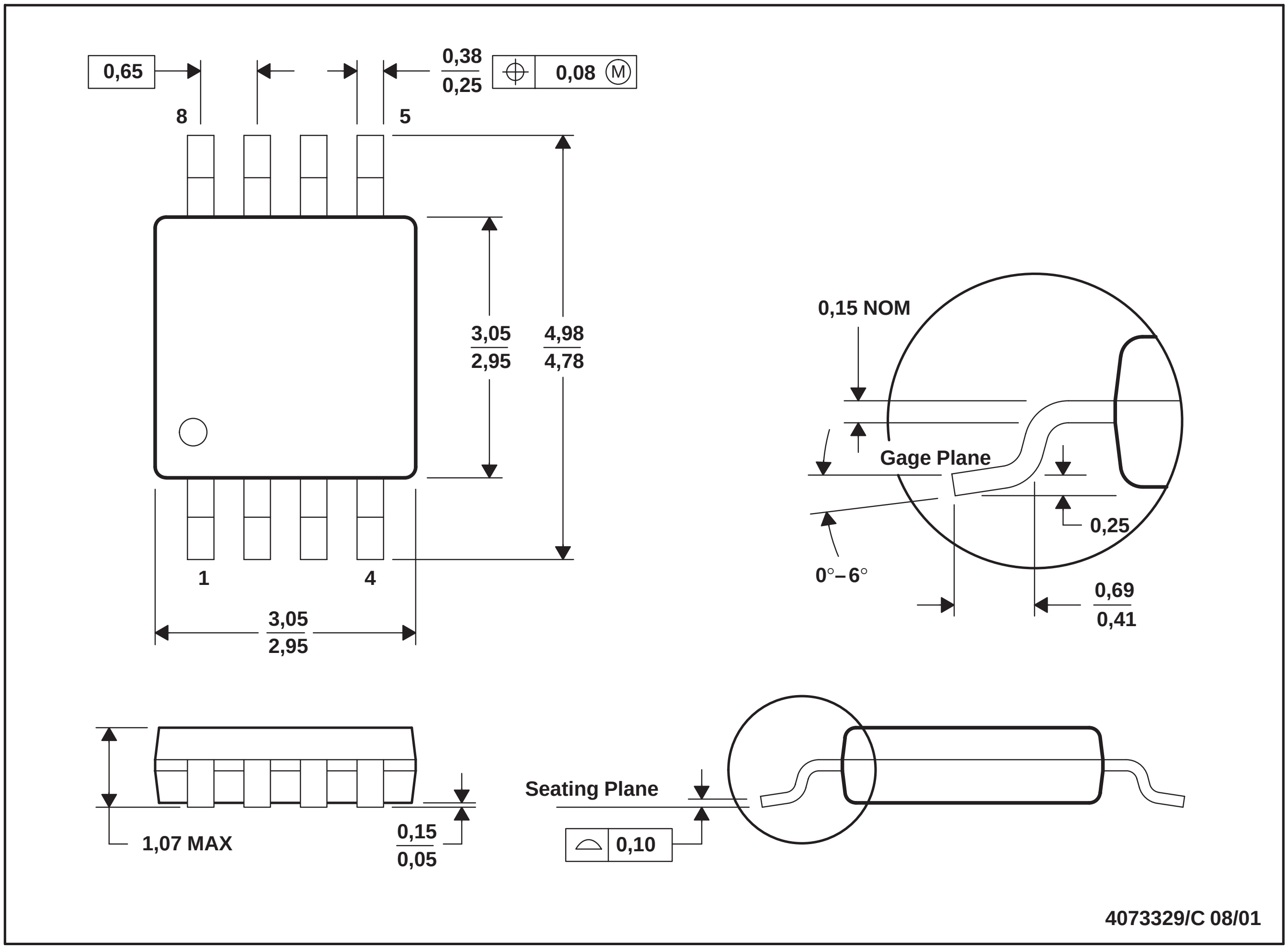

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.
A. Falls within JEDEC MO-187

**DBV (R-PDSO-G5)** **PLASTIC SMALL-OUTLINE**




NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.
D. Falls within JEDEC MO-178

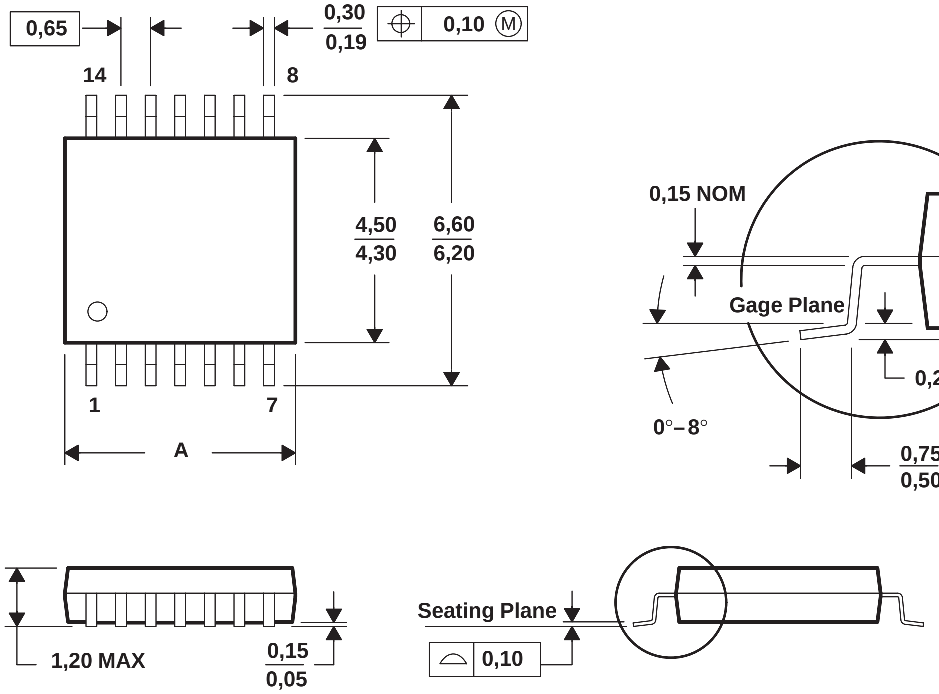
**DGK (R-PDSO-G8)** **PLASTIC SMALL-OUTLINE PACKAGE**




NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.
D. Falls within JEDEC MO-187

**PW (R-PDSO-G**)** **PLASTIC SMALL-OUTLINE PACKAGE**

**14 PINS SHOWN**




| DIM \ PINS ** | 8 | 14 | 16 | 20 | 24 | 28 |
|---|---|---|---|---|---|---|
| A MAX | 3,10 | 5,10 | 5,10 | 6,60 | 7,90 | 9,80 |
| A MIN | 2,90 | 4,90 | 4,90 | 6,40 | 7,70 | 9,60 |

4040064/F 01/97

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

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