

2.9 nV/sqrt(Hz) Low Noise, RRIO Amplifier

Check for Samples: [LMP7732](#)

FEATURES

- (Typical Values, $T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$)
- Input Voltage Noise
 - $f = 3\text{ Hz}$ $3.3\text{ nV}/\sqrt{\text{Hz}}$
 - $f = 1\text{ kHz}$ $2.9\text{ nV}/\sqrt{\text{Hz}}$
- CMRR 130 dB
- Open Loop Gain 130 dB
- GBW 22 MHz
- Slew Rate 2.4 V/ μs
- THD 0.001% @ $f = 10\text{ kHz}$, $A_V = 1$, $R_L = 2\text{ k}\Omega$
- Supply Current 4.4 mA
- Supply Voltage Range 1.8V to 5.5V
- Operating Temperature Range -40°C to 125°C
- Input Bias Current $\pm 1.5\text{ nA}$
- RRIO

APPLICATIONS

- Gas Analysis Instruments
- Photometric Instrumentation
- Medical Instrumentation

DESCRIPTION

The LMP7732 is a dual low noise, rail-to-rail input and output, low voltage amplifier. The LMP7732 is part of the LMP™ amplifier family and is ideal for precision and low noise applications with low voltage requirements.

This operational amplifier offers low voltage noise of $2.9\text{ nV}/\sqrt{\text{Hz}}$ with a $1/f$ corner of only 3 Hz. The LMP7732 has bipolar junction input stages with a bias current of only 1.5 nA. This low input bias current, complemented by the very low level of voltage noise, makes the LMP7732 an excellent choice for photometry applications.

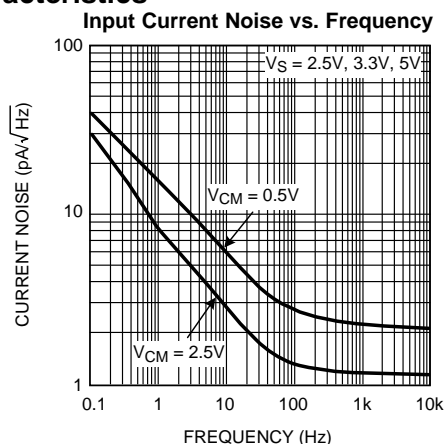
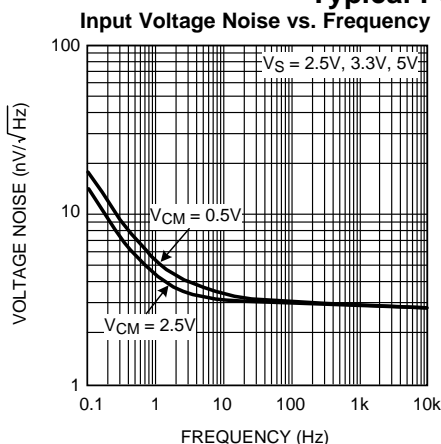
The LMP7732 provides a wide GBW of 22 MHz while consuming only 4 mA of current. This high gain bandwidth along with the high open loop gain of 130 dB enables accurate signal conditioning in applications with high closed loop gain requirements.

The LMP7732 has a supply voltage range of 1.8V to 5.5V, making it an ideal choice for battery operated portable applications.

The LMP7732 is offered in the 8-Pin SOIC and VSSOP packages.

The LMP7731 is the single version of this product and is offered in the 5-Pin SOT-23 and 8-Pin SOIC packages.

Typical Performance Characteristics



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These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings⁽¹⁾⁽²⁾

| | | | |
|--|------------------------------------|----------------------|----------------|
| ESD Tolerance ⁽³⁾ | Human Body Model | For inputs pins only | 2000V |
| | | For all other pins | 2000V |
| | Machine Model | | 200V |
| | | Charge Device Model | 1000V |
| V _{IN} Differential | | | ±2V |
| Supply Voltage (V _S = V ⁺ – V ⁻) | | | 6.0V |
| Storage Temperature Range | | | -65°C to 150°C |
| Junction Temperature ⁽⁴⁾ | | | +150°C max |
| Soldering Information | Infrared or Convection (20 sec) | | 235°C |
| | Wave Soldering Lead Temp. (10 sec) | | 260°C |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not ensured. For ensured specifications and the test conditions, see the Electrical Characteristics Tables.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
- (3) Human Body Model, applicable std. MIL-STD-883, Method 3015.7. Machine Model, applicable std. JESD22-A115-A (ESD MM std. of JEDEC) Field-Induced Charge-Device Model, applicable std. JESD22-C101-C (ESD FICDM std. of JEDEC).
- (4) The maximum power dissipation is a function of T_{J(MAX)}, θ_{JA}, and T_A. The maximum allowable power dissipation at any ambient temperature is P_D = (T_{J(MAX)} - T_A) / θ_{JA}. All numbers apply for packages soldered directly onto a PC board.

Operating Ratings⁽¹⁾

| | | |
|--|-------------|----------------|
| Temperature Range | | -40°C to 125°C |
| Supply Voltage (V _S = V ⁺ – V ⁻) | | 1.8V to 5.5V |
| Package Thermal Resistance (θ _{JA}) | 8-Pin SOIC | 190 °C/W |
| | 8-Pin VSSOP | 235°C/W |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not ensured. For ensured specifications and the test conditions, see the Electrical Characteristics Tables.

2.5V Electrical Characteristics⁽¹⁾

Unless otherwise specified, all limits are ensured for $T_A = 25^\circ\text{C}$, $V^+ = 2.5\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = V^+/2$, $R_L > 10\text{ k}\Omega$ to $V^+/2$. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Min ⁽²⁾ | Typ ⁽³⁾ | Max ⁽²⁾ | Units |
|--------------------------|--|--|--------------------|--------------------|--|------------------------------|
| V_{OS} | Input Offset Voltage ⁽⁴⁾ | $V_{\text{CM}} = 2.0\text{V}$ | | ± 9 | ± 500 ± 600 | μV |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | ± 9 | ± 500 ± 600 | |
| TCV_{OS} | Input Offset Voltage Temperature Drift | $V_{\text{CM}} = 2.0\text{V}$ | | ± 0.5 | ± 5.5 | $\mu\text{V}/^\circ\text{C}$ |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | ± 0.2 | ± 5.5 | |
| I_{B} | Input Bias Current | $V_{\text{CM}} = 2.0\text{V}$ | | ± 1 | ± 30 ± 45 | nA |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | ± 12 | ± 50 ± 75 | |
| I_{OS} | Input Offset Current | $V_{\text{CM}} = 2.0\text{V}$ | | ± 1 | ± 50 ± 75 | nA |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | ± 11 | ± 60 ± 80 | |
| TCI_{OS} | Input Offset Current Drift | $V_{\text{CM}} = 0.5\text{V}$ and $V_{\text{CM}} = 2.0\text{V}$ | | 0.0474 | | nA/ $^\circ\text{C}$ |
| CMRR | Common Mode Rejection Ratio | $0.15\text{V} \leq V_{\text{CM}} \leq 0.7\text{V}$ $0.23\text{V} \leq V_{\text{CM}} \leq 0.7\text{V}$ | 101 89 | 120 | | dB |
| | | $1.5\text{V} \leq V_{\text{CM}} \leq 2.35\text{V}$ $1.5\text{V} \leq V_{\text{CM}} \leq 2.27\text{V}$ | 105 99 | 129 | | |
| PSRR | Power Supply Rejection Ratio | $2.5\text{V} \leq V^+ \leq 5\text{V}$ | 105 101 | 113 | | dB |
| | | $1.8\text{V} \leq V^+ \leq 5.5\text{V}$ | | 111 | | |
| CMVR | Common Mode Voltage Range | Large Signal CMRR $\geq 80\text{ dB}$ | 0 | | 2.5 | V |
| A_{VOL} | Open Loop Voltage Gain | $R_L = 10\text{ k}\Omega$ to $V^+/2$ $V_{\text{OUT}} = 0.5\text{V}$ to 2.0V | 112 104 | 130 | | dB |
| | | $R_L = 2\text{ k}\Omega$ to $V^+/2$ $V_{\text{OUT}} = 0.5\text{V}$ to 2.0V | 109 90 | 119 | | |
| V_{OUT} | Output Voltage Swing High | $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 4 | 50 75 | mV from either rail |
| | | $R_L = 2\text{ k}\Omega$ to $V^+/2$ | | 13 | 50 75 | |
| | Output Voltage Swing Low | $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 6 | 50 75 | |
| | | $R_L = 2\text{ k}\Omega$ to $V^+/2$ | | 9 | 50 75 | |
| I_{OUT} | Output Current | Sourcing, $V_{\text{OUT}} = V^+/2$ $V_{\text{IN}}(\text{diff}) = 100\text{ mV}$ | 22 12 | 31 | | mA |
| | | Sinking, $V_{\text{OUT}} = V^+/2$ $V_{\text{IN}}(\text{diff}) = -100\text{ mV}$ | 15 10 | 44 | | |
| I_{S} | Supply Current | $V_{\text{CM}} = 2.0\text{V}$ | | 4.0 | 5.4 6.8 | mA |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | 4.6 | 6.2 7.8 | |
| SR | Slew Rate | $A_V = +1$, $C_L = 10\text{ pF}$, $R_L = 10\text{ k}\Omega$ to $V^+/2$ $V_{\text{OUT}} = 2 V_{\text{PP}}$ | | 2.4 | | V/ μs |

- (1) Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No ensured specification of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. Absolute maximum Ratings indicate junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.
- (2) All limits are specified by testing, statistical analysis or design.
- (3) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not ensured on shipped production material.
- (4) Ambient production test is performed at 25°C with a variance of $\pm 3^\circ\text{C}$.

2.5V Electrical Characteristics⁽¹⁾ (continued)

Unless otherwise specified, all limits are ensured for $T_A = 25^\circ\text{C}$, $V^+ = 2.5\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = V^+/2$, $R_L > 10\text{ k}\Omega$ to $V^+/2$. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Min ⁽²⁾ | Typ ⁽³⁾ | Max ⁽²⁾ | Units |
|-----------------|--------------------------------------|---|--------------------|--------------------|--------------------|------------------------|
| GBW | Gain Bandwidth | $C_L = 20\text{ pF}$, $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 21 | | MHz |
| G_M | Gain Margin | $C_L = 20\text{ pF}$, $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 14 | | dB |
| Φ_M | Phase Margin | $C_L = 20\text{ pF}$, $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 60 | | deg |
| R_{IN} | Input Resistance | Differential Mode | | 38 | | k Ω |
| | | Common Mode | | 151 | | M Ω |
| THD+N | Total Harmonic Distortion + Noise | $A_V = 1$, $f_O = 1\text{ kHz}$, Amplitude = 1V | | 0.002 | | % |
| e_n | Input Referred Voltage Noise Density | $f = 1\text{ kHz}$, $V_{\text{CM}} = 2.0\text{V}$ | | 3.0 | | nV/ $\sqrt{\text{Hz}}$ |
| | | $f = 1\text{ kHz}$, $V_{\text{CM}} = 0.5\text{V}$ | | 3.0 | | |
| | Input Voltage Noise | 0.1 Hz to 10 Hz | | 75 | | nV _{PP} |
| i_n | Input Referred Current Noise Density | $f = 1\text{ kHz}$, $V_{\text{CM}} = 2.0\text{V}$ | | 1.1 | | pA/ $\sqrt{\text{Hz}}$ |
| | | $f = 1\text{ kHz}$, $V_{\text{CM}} = 0.5\text{V}$ | | 2.3 | | |

3.3V Electrical Characteristics⁽¹⁾

Unless otherwise specified, all limits are ensured for $T_A = 25^\circ\text{C}$, $V^+ = 3.3\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = V^+/2$, $R_L > 10\text{ k}\Omega$ to $V^+/2$. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Min ⁽²⁾ | Typ ⁽³⁾ | Max ⁽²⁾ | Units |
|--------------------------|--|--|--------------------|--------------------|--|------------------------------|
| V_{OS} | Input Offset Voltage ⁽⁴⁾ | $V_{\text{CM}} = 2.5\text{V}$ | | ± 6 | ± 500 ± 600 | μV |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | ± 6 | ± 500 ± 600 | |
| TCV_{OS} | Input Offset Voltage Temperature Drift | $V_{\text{CM}} = 2.5\text{V}$ | | ± 0.5 | ± 5.5 | $\mu\text{V}/^\circ\text{C}$ |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | ± 0.2 | ± 5.5 | |
| I_{B} | Input Bias Current | $V_{\text{CM}} = 2.5\text{V}$ | | ± 1.5 | ± 30 ± 45 | nA |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | ± 13 | ± 50 ± 77 | |
| I_{OS} | Input Offset Current | $V_{\text{CM}} = 2.5\text{V}$ | | ± 1 | ± 50 ± 70 | nA |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | ± 11 | ± 60 ± 80 | |
| TCI_{OS} | Input Offset Current Drift | $V_{\text{CM}} = 0.5\text{V}$ and $V_{\text{CM}} = 2.5\text{V}$ | | 0.048 | | $\text{nA}/^\circ\text{C}$ |
| CMRR | Common Mode Rejection Ratio | $0.15\text{V} \leq V_{\text{CM}} \leq 0.7\text{V}$ | 101 | 120 | | dB |
| | | $0.23\text{V} \leq V_{\text{CM}} \leq 0.7\text{V}$ | 89 | | | |
| PSRR | Power Supply Rejection Ratio | $1.5\text{V} \leq V_{\text{CM}} \leq 3.15\text{V}$ | 105 | 113 | | dB |
| | | $1.5\text{V} \leq V_{\text{CM}} \leq 3.07\text{V}$ | 99 | | | |
| CMVR | Common Mode Voltage Range | $2.5\text{V} \leq V^+ \leq 5.0\text{V}$ | 105 | 113 | | dB |
| | | $1.8\text{V} \leq V^+ \leq 5.5\text{V}$ | 101 | | | |
| A_{VOL} | Open Loop Voltage Gain | Large Signal CMRR $\geq 80\text{ dB}$ | 0 | | 3.3 | V |
| | | $R_L = 10\text{ k}\Omega$ to $V^+/2$ $V_{\text{OUT}} = 0.5\text{V}$ to 2.8V | 112 | 130 | | dB |
| | $R_L = 2\text{ k}\Omega$ to $V^+/2$ $V_{\text{OUT}} = 0.5\text{V}$ to 2.8V | 110 | 119 | | | |
| V_{OUT} | Output Voltage Swing High | $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 5 | 50 75 | mV from either rail |
| | | $R_L = 2\text{ k}\Omega$ to $V^+/2$ | | 14 | 50 75 | |
| | Output Voltage Swing Low | $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 9 | 50 75 | |
| | | $R_L = 2\text{ k}\Omega$ to $V^+/2$ | | 13 | 50 75 | |
| I_{OUT} | Output Current | Sourcing, $V_{\text{OUT}} = V^+/2$ $V_{\text{IN}}(\text{diff}) = 100\text{ mV}$ | 28 | 45 | | mA |
| | | Sinking, $V_{\text{OUT}} = V^+/2$ $V_{\text{IN}}(\text{diff}) = -100\text{ mV}$ | 25 | 48 | | |
| I_{S} | Supply Current | $V_{\text{CM}} = 2.5\text{V}$ | | 4.2 | 5.6 7.0 | mA |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | 4.8 | 6.4 8.0 | |
| SR | Slew Rate | $A_V = +1$, $C_L = 10\text{ pF}$, $R_L = 10\text{ k}\Omega$ to $V^+/2$ $V_{\text{OUT}} = 2 V_{\text{PP}}$ | | 2.4 | | $\text{V}/\mu\text{s}$ |

- (1) Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No ensured specification of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. Absolute maximum Ratings indicate junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.
- (2) All limits are specified by testing, statistical analysis or design.
- (3) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not ensured on shipped production material.
- (4) Ambient production test is performed at 25°C with a variance of $\pm 3^\circ\text{C}$.

3.3V Electrical Characteristics⁽¹⁾ (continued)

Unless otherwise specified, all limits are ensured for $T_A = 25^\circ\text{C}$, $V^+ = 3.3\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = V^+/2$, $R_L > 10\text{ k}\Omega$ to $V^+/2$. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Min ⁽²⁾ | Typ ⁽³⁾ | Max ⁽²⁾ | Units |
|-----------------|--------------------------------------|---|--------------------|--------------------|--------------------|------------------------|
| GBW | Gain Bandwidth | $C_L = 20\text{ pF}$, $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 22 | | MHz |
| G_M | Gain Margin | $C_L = 20\text{ pF}$, $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 14 | | dB |
| Φ_M | Phase Margin | $C_L = 20\text{ pF}$, $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 62 | | deg |
| THD+N | Total Harmonic Distortion + Noise | $A_V = 1$, $f_0 = 1\text{ kHz}$, Amplitude = 1V | | 0.002 | | % |
| R_{IN} | Input Resistance | Differential Mode | | 38 | | k Ω |
| | | Common Mode | | 151 | | M Ω |
| e_n | Input Referred Voltage Noise Density | $f = 1\text{ kHz}$, $V_{\text{CM}} = 2.5\text{V}$ | | 2.9 | | nV/ $\sqrt{\text{Hz}}$ |
| | | $f = 1\text{ kHz}$, $V_{\text{CM}} = 0.5\text{V}$ | | 2.9 | | |
| | Input Voltage Noise | 0.1 Hz to 10 Hz | | 75 | | nV _{PP} |
| i_n | Input Referred Current Noise Density | $f = 1\text{ kHz}$, $V_{\text{CM}} = 2.5\text{V}$ | | 1.1 | | pA/ $\sqrt{\text{Hz}}$ |
| | | $f = 1\text{ kHz}$, $V_{\text{CM}} = 0.5\text{V}$ | | 2.1 | | |

5V Electrical Characteristics⁽¹⁾

Unless otherwise specified, all limits are ensured for $T_A = 25^\circ\text{C}$, $V^+ = 5\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = V^+/2$, $R_L > 10\text{ k}\Omega$ to $V^+/2$. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Min ⁽²⁾ | Typ ⁽³⁾ | Max ⁽²⁾ | Units |
|-------------------|--|--|--------------------|--------------------|--|------------------------------|
| V_{OS} | Input Offset Voltage ⁽⁴⁾ | $V_{\text{CM}} = 4.5\text{V}$ | | ± 6 | ± 500 ± 600 | μV |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | ± 6 | ± 500 ± 600 | |
| TCV _{OS} | Input Offset Voltage Temperature Drift | $V_{\text{CM}} = 4.5\text{V}$ | | ± 0.5 | ± 5.5 | $\mu\text{V}/^\circ\text{C}$ |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | ± 0.2 | ± 5.5 | |
| I_B | Input Bias Current | $V_{\text{CM}} = 4.5\text{V}$ | | ± 1.5 | ± 30 ± 50 | nA |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | ± 14 | ± 50 ± 85 | |
| I_{OS} | Input Offset Current | $V_{\text{CM}} = 4.5\text{V}$ | | ± 1 | ± 50 ± 70 | nA |
| | | $V_{\text{CM}} = 0.5\text{V}$ | | ± 11 | ± 65 ± 80 | |
| TCI _{OS} | Input Offset Current Drift | $V_{\text{CM}} = 0.5\text{V}$ and $V_{\text{CM}} = 4.5\text{V}$ | | 0.0482 | | nA/ $^\circ\text{C}$ |
| CMRR | Common Mode Rejection Ratio | $0.15\text{V} \leq V_{\text{CM}} \leq 0.7\text{V}$ $0.23\text{V} \leq V_{\text{CM}} \leq 0.7\text{V}$ | 101 89 | 120 | | dB |
| | | $1.5\text{V} \leq V_{\text{CM}} \leq 4.85\text{V}$ $1.5\text{V} \leq V_{\text{CM}} \leq 4.77\text{V}$ | 105 99 | 130 | | |
| PSRR | Power Supply Rejection Ratio | $2.5\text{V} \leq V^+ \leq 5\text{V}$ | 105 101 | 113 | | dB |
| | | $1.8\text{V} \leq V^+ \leq 5.5\text{V}$ | | 111 | | |
| CMVR | Common Mode Voltage Range | Large Signal CMRR $\geq 80\text{ dB}$ | 0 | | 5 | V |
| A_{VOL} | Open Loop Voltage Gain | $R_L = 10\text{ k}\Omega$ to $V^+/2$ $V_{\text{OUT}} = 0.5\text{V}$ to 4.5V | 112 104 | 130 | | dB |
| | | $R_L = 2\text{ k}\Omega$ to $V^+/2$ $V_{\text{OUT}} = 0.5\text{V}$ to 4.5V | 110 94 | 119 | | |

- (1) Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No ensured specification of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. Absolute maximum Ratings indicate junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.
- (2) All limits are specified by testing, statistical analysis or design.
- (3) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not ensured on shipped production material.
- (4) Ambient production test is performed at 25°C with a variance of $\pm 3^\circ\text{C}$.

5V Electrical Characteristics⁽¹⁾ (continued)

Unless otherwise specified, all limits are ensured for $T_A = 25^\circ\text{C}$, $V^+ = 5\text{V}$, $V^- = 0\text{V}$, $V_{CM} = V^+/2$, $R_L > 10\text{ k}\Omega$ to $V^+/2$. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Min ⁽²⁾ | Typ ⁽³⁾ | Max ⁽²⁾ | Units |
|-----------|--------------------------------------|--|------------------------|--------------------|--------------------------|------------------------|
| V_{OUT} | Output Voltage Swing High | $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 8 | 50 75 | mV from either rail |
| | | $R_L = 2\text{ k}\Omega$ to $V^+/2$ | | 24 | 50 75 | |
| | Output Voltage Swing Low | $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 9 | 50 75 | |
| | | $R_L = 2\text{ k}\Omega$ to $V^+/2$ | | 23 | 50 75 | |
| I_{OUT} | Output Current | Sourcing, $V_{OUT} = V^+/2$ $V_{IN}(\text{diff}) = 100\text{ mV}$ | 33 27 | 47 | | mA |
| | | Sinking, $V_{OUT} = V^+/2$ $V_{IN}(\text{diff}) = -100\text{ mV}$ | 30 25 | 49 | | |
| I_S | Supply Current | $V_{CM} = 4.5\text{V}$ | | 4.4 | 6.0 7.4 | mA |
| | | $V_{CM} = 0.5\text{V}$ | | 5.0 | 6.8 8.4 | |
| SR | Slew Rate | $A_V = +1$, $C_L = 10\text{ pF}$, $R_L = 10\text{ k}\Omega$ to $V^+/2$ $V_{OUT} = 2 V_{PP}$ | | 2.4 | | V/ μs |
| GBW | Gain Bandwidth | $C_L = 20\text{ pF}$, $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 22 | | MHz |
| G_M | Gain Margin | $C_L = 20\text{ pF}$, $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 12 | | dB |
| Φ_M | Phase Margin | $C_L = 20\text{ pF}$, $R_L = 10\text{ k}\Omega$ to $V^+/2$ | | 65 | | deg |
| R_{IN} | Input Resistance | Differential Mode | | 38 | | k Ω |
| | | Common Mode | | 151 | | M Ω |
| THD+N | Total Harmonic Distortion + Noise | $A_V = 1$, $f_O = 1\text{ kHz}$, Amplitude = 1V | | 0.001 | | % |
| e_n | Input Referred Voltage Noise Density | $f = 1\text{ kHz}$, $V_{CM} = 4.5\text{V}$ | | 2.9 | | nV/ $\sqrt{\text{Hz}}$ |
| | | $f = 1\text{ kHz}$, $V_{CM} = 0.5\text{V}$ | | 2.9 | | |
| | Input Voltage Noise | 0.1 Hz to 10 Hz | | 75 | | nV $_{PP}$ |
| i_n | Input Referred Current Noise Density | $f = 1\text{ kHz}$, $V_{CM} = 4.5\text{V}$ | | 1.1 | | pA/ $\sqrt{\text{Hz}}$ |
| | | $f = 1\text{ kHz}$, $V_{CM} = 0.5\text{V}$ | | 2.2 | | |

Connection Diagram

8-Pin SOIC/VSSOP

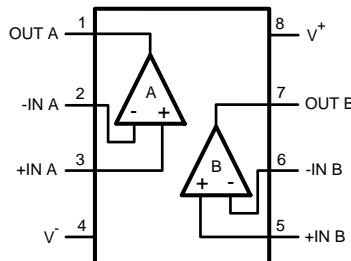


Figure 1. Top View

Typical Performance Characteristics

Unless otherwise noted: $T_A = 25^\circ\text{C}$, $R_L > 10\text{ k}\Omega$, $V_{CM} = V_S/2$.

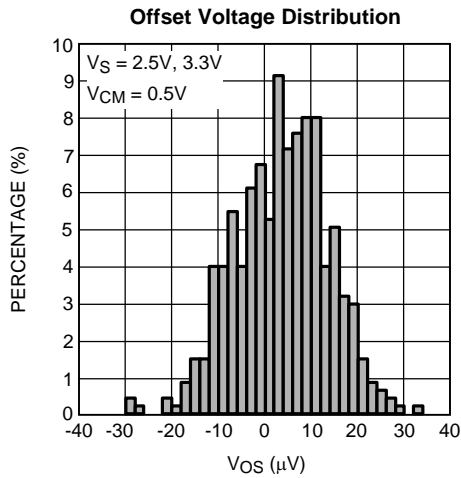


Figure 2.

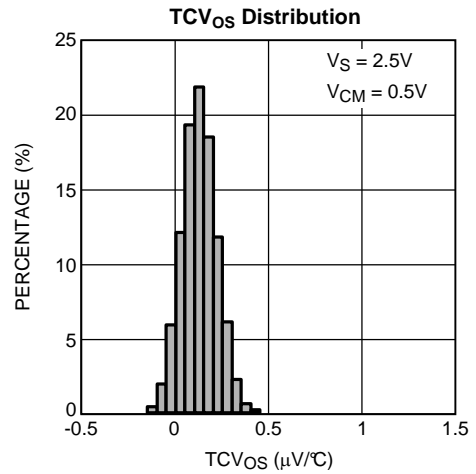


Figure 3.

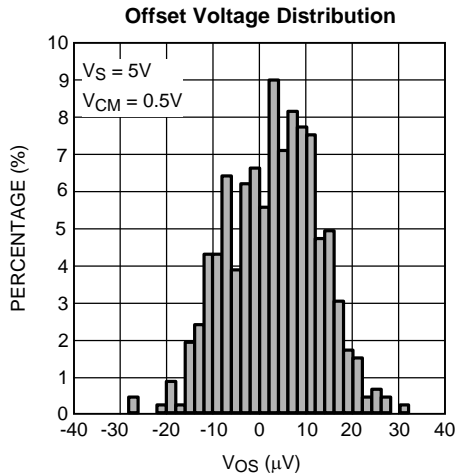


Figure 4.

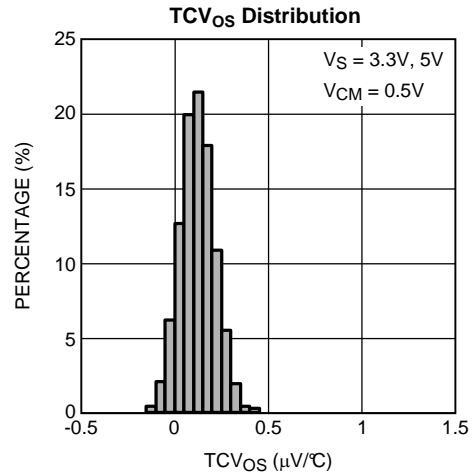


Figure 5.

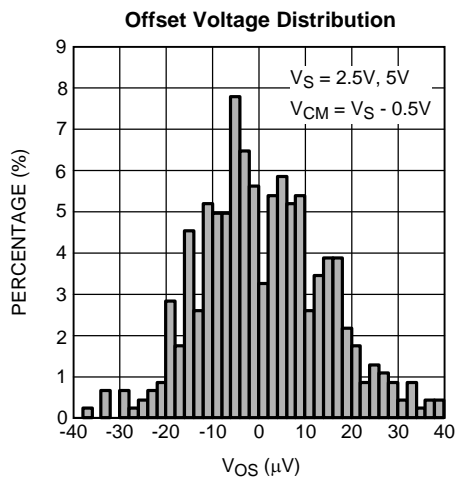


Figure 6.

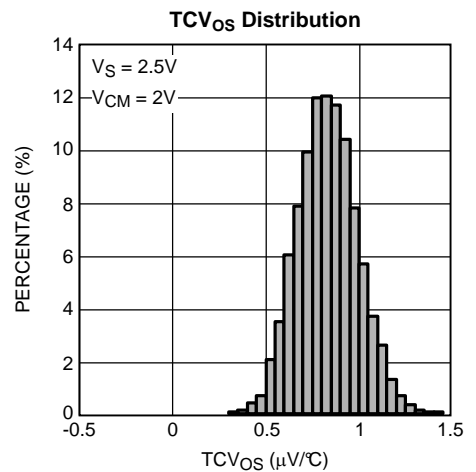


Figure 7.

Typical Performance Characteristics (continued)

Unless otherwise noted: $T_A = 25^\circ\text{C}$, $R_L > 10\text{ k}\Omega$, $V_{CM} = V_S/2$.

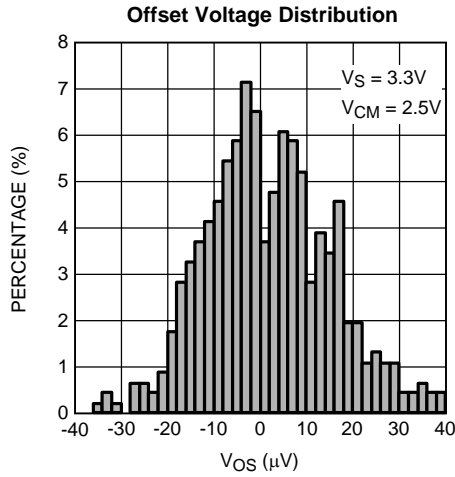


Figure 8.

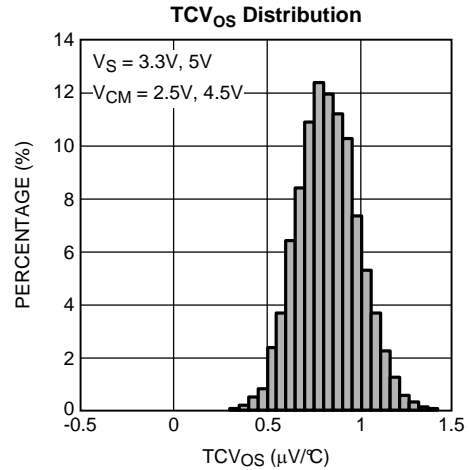


Figure 9.

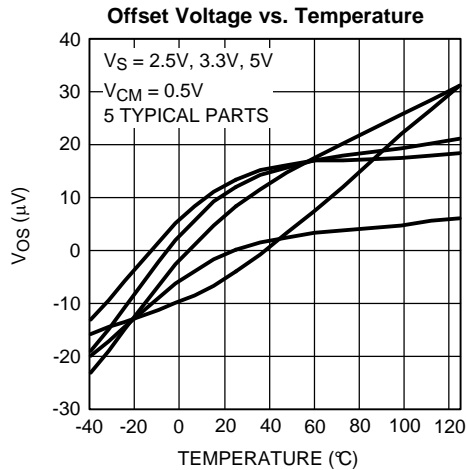


Figure 10.

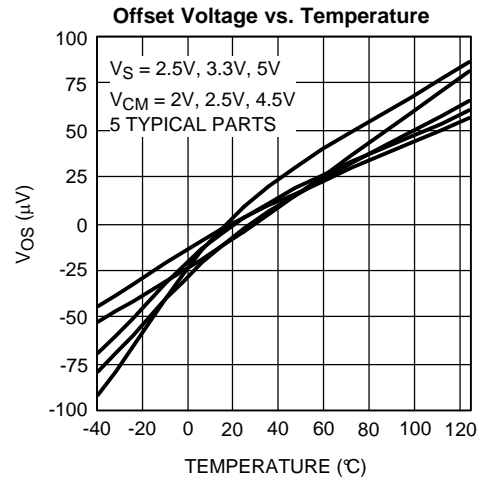


Figure 11.

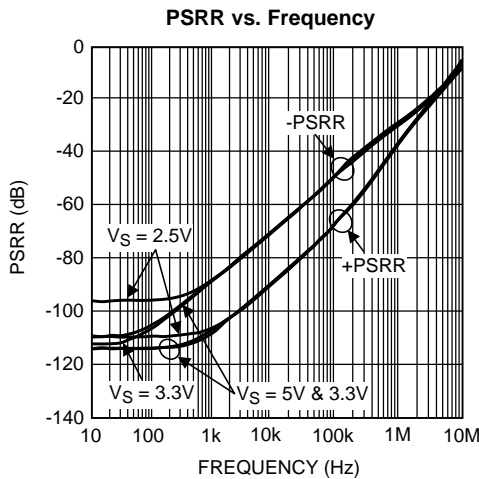


Figure 12.

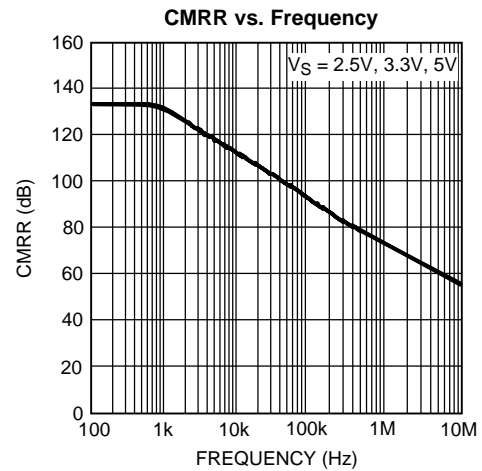


Figure 13.

Typical Performance Characteristics (continued)

Unless otherwise noted: $T_A = 25^\circ\text{C}$, $R_L > 10\text{ k}\Omega$, $V_{CM} = V_S/2$.

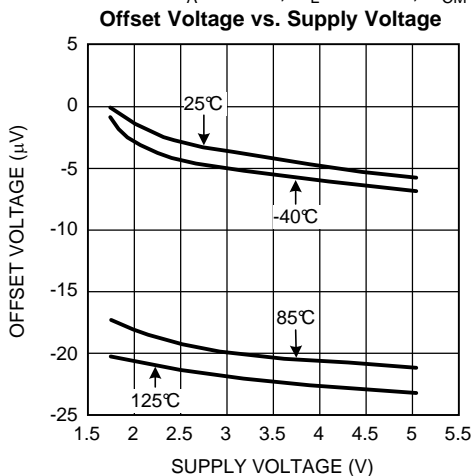


Figure 14.

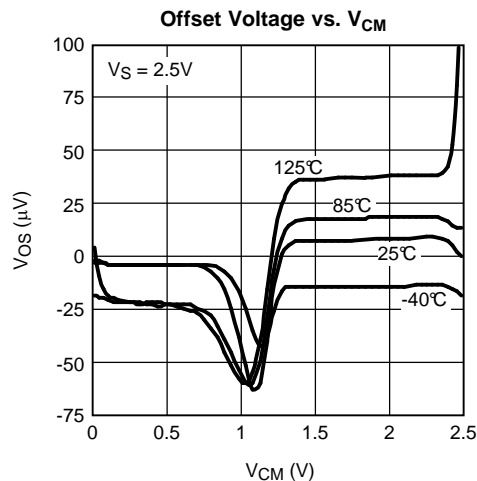


Figure 15.

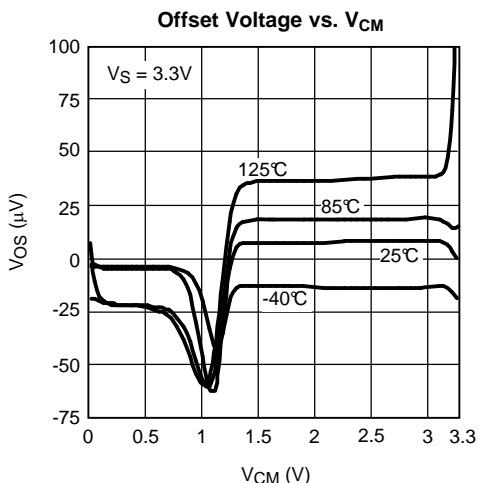


Figure 16.

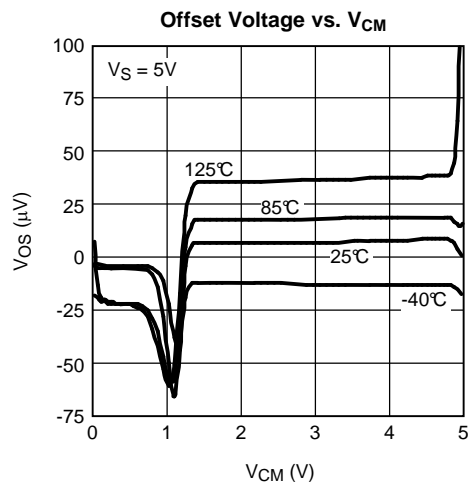


Figure 17.

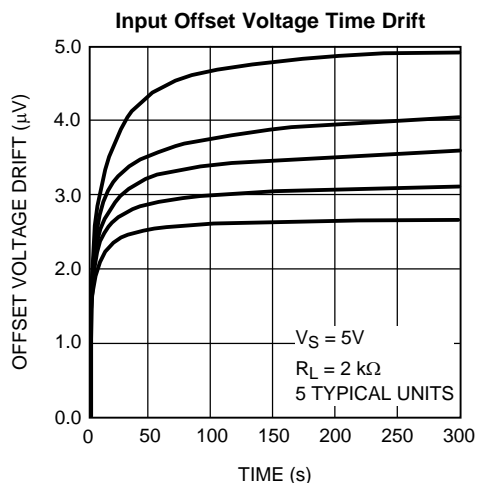


Figure 18.

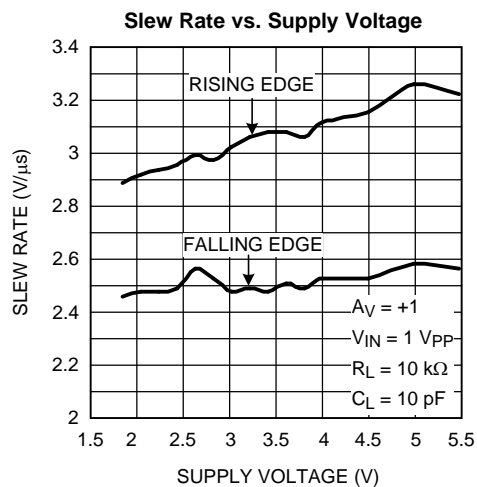


Figure 19.

Typical Performance Characteristics (continued)

Unless otherwise noted: $T_A = 25^\circ\text{C}$, $R_L > 10\text{ k}\Omega$, $V_{CM} = V_S/2$.

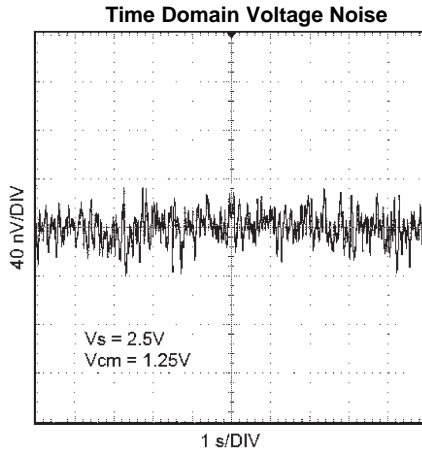


Figure 20.

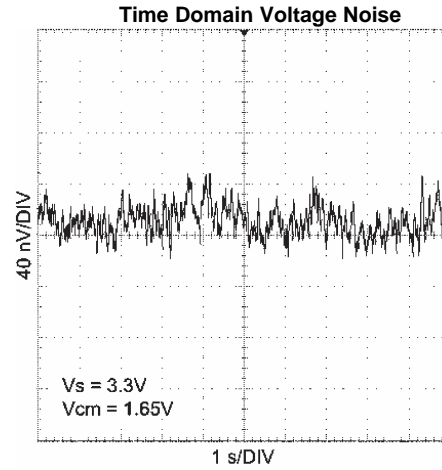


Figure 21.

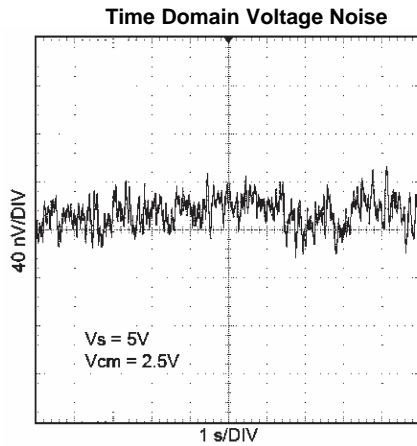


Figure 22.

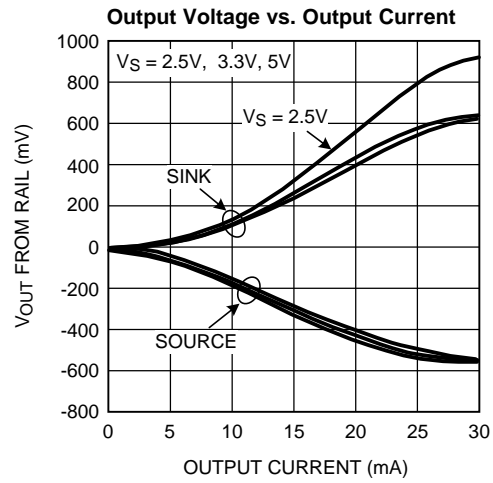


Figure 23.

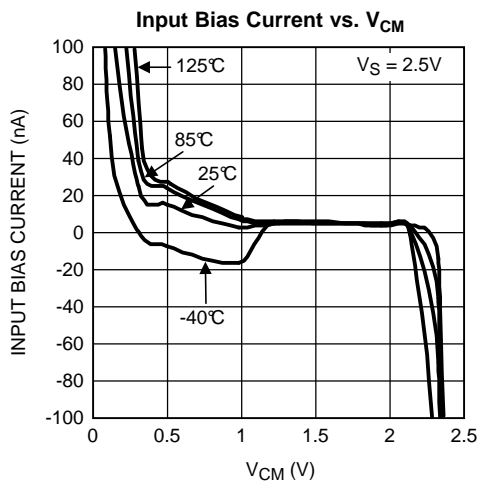


Figure 24.

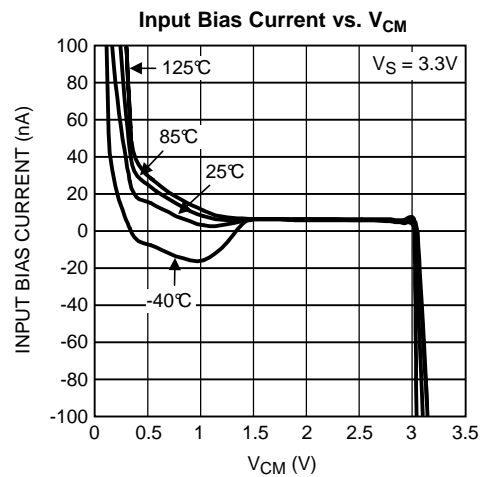


Figure 25.

Typical Performance Characteristics (continued)

Unless otherwise noted: $T_A = 25^\circ\text{C}$, $R_L > 10\text{ k}\Omega$, $V_{CM} = V_S/2$.

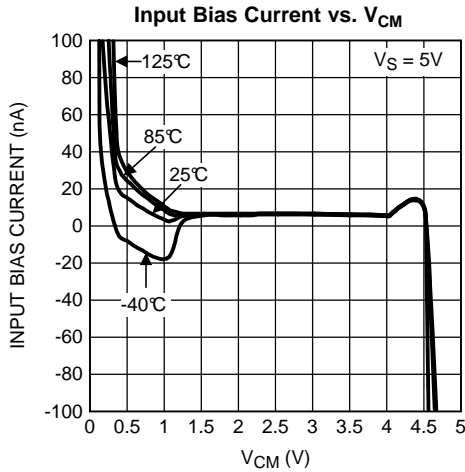


Figure 26.

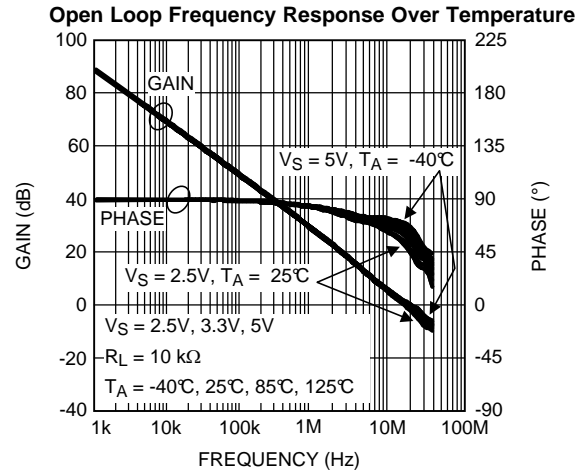


Figure 27.

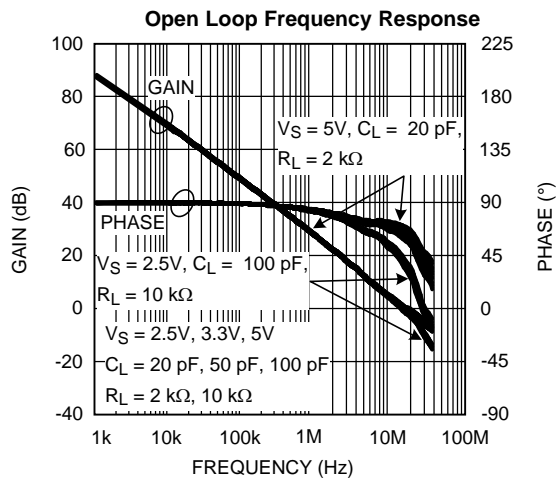


Figure 28.

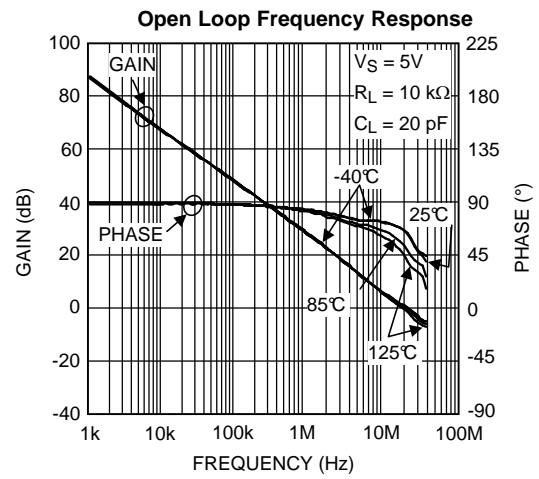


Figure 29.

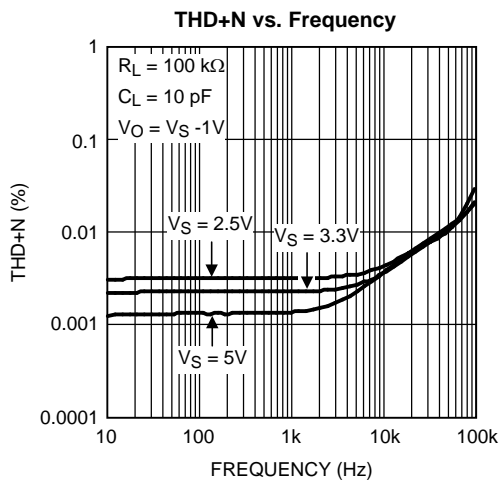


Figure 30.

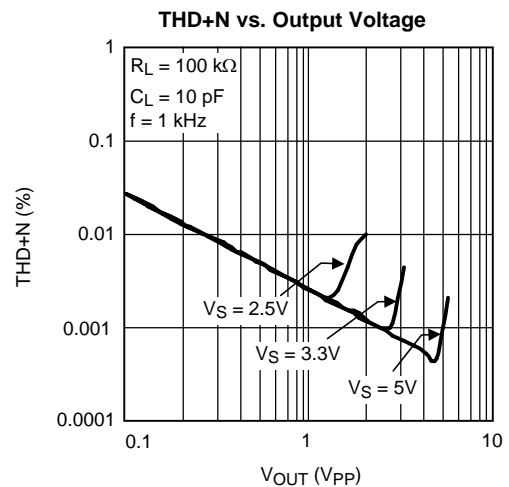


Figure 31.

Typical Performance Characteristics (continued)

Unless otherwise noted: $T_A = 25^\circ\text{C}$, $R_L > 10\text{ k}\Omega$, $V_{CM} = V_S/2$.

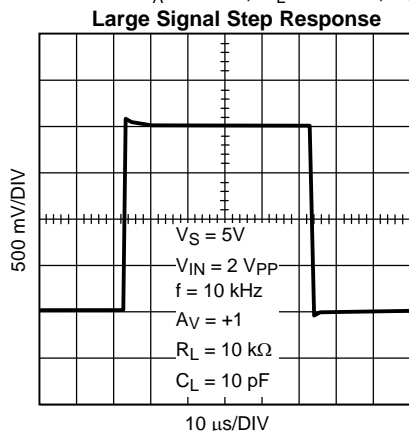


Figure 32.

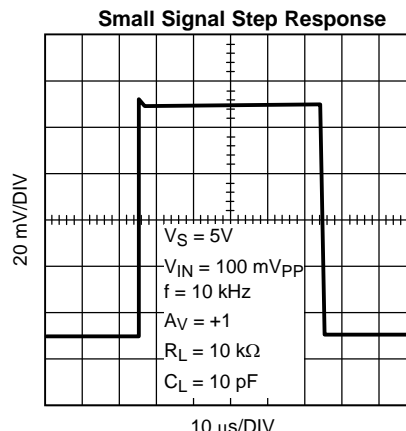


Figure 33.

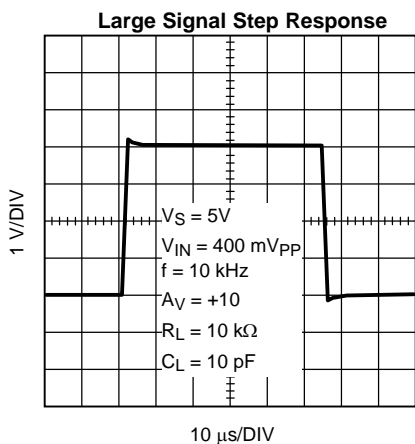


Figure 34.

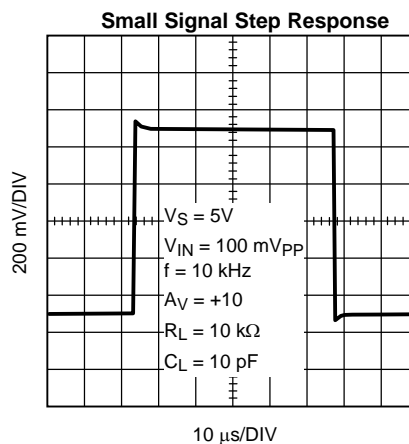


Figure 35.

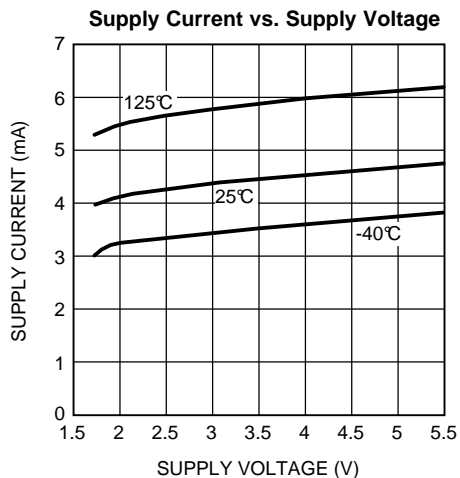


Figure 36.

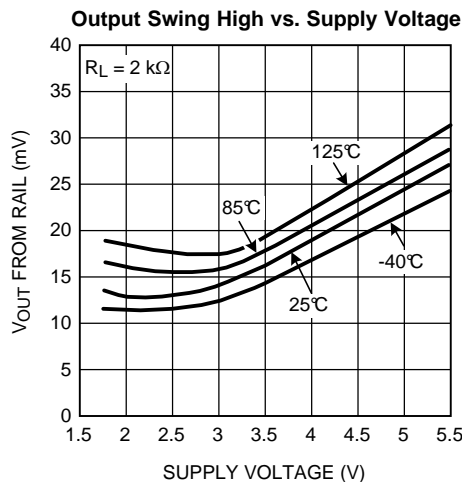


Figure 37.

Typical Performance Characteristics (continued)

Unless otherwise noted: $T_A = 25^\circ\text{C}$, $R_L > 10\text{ k}\Omega$, $V_{CM} = V_S/2$.

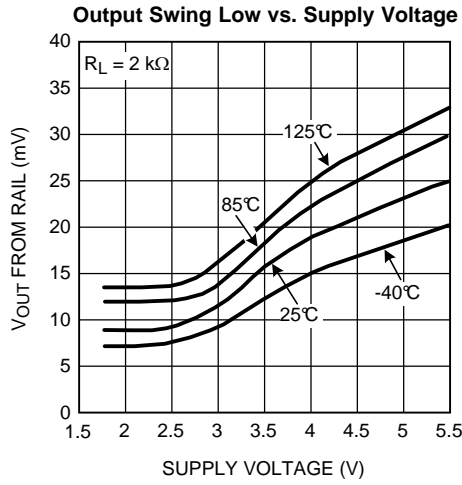


Figure 38.

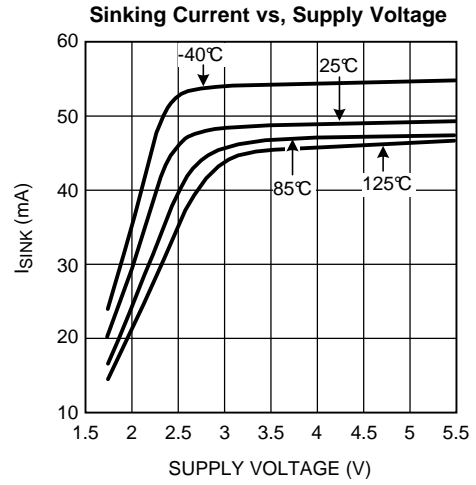


Figure 39.

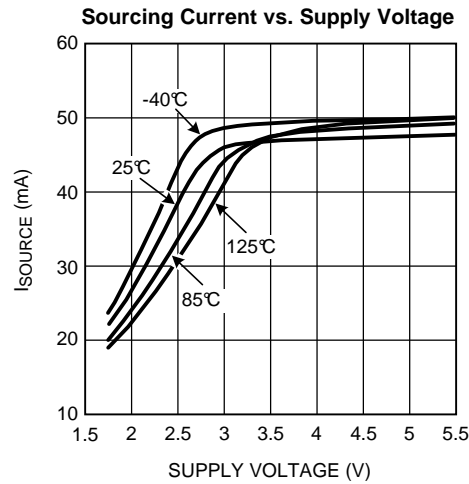


Figure 40.

APPLICATION NOTES

LMP7732

The LMP7732 is a dual low noise, rail-to-rail input and output, low voltage amplifier.

The low input voltage noise of only $2.9 \text{ nV}/\sqrt{\text{Hz}}$ with a $1/f$ corner at 3 Hz makes the LMP7732 ideal for sensor applications where DC accuracy is of importance.

The LMP7732 has high gain bandwidth of 22 MHz. This wide bandwidth enables the use of the amplifier at higher gain settings while retaining ample usable bandwidth for the application. This is particularly beneficial when system designers need to use sensors with very limited output voltage range as it allows larger gains in one stage which in turn increases signal to noise ratio.

The LMP7732 has a proprietary input bias cancellation circuitry on the input stages. This allows the LMP7732 to have only about 1.5 nA bias current with a bipolar input stage. This low input bias current, paired with the inherent lower input voltage noise of bipolar input stages makes the LMP7732 an excellent choice for precision applications. The combination of low input bias current, low input offset voltage, and low input voltage noise enables the user to achieve unprecedented accuracy and higher signal integrity.

Texas Instruments is heavily committed to precision amplifiers and the market segment they serve. Technical support and extensive characterization data is available for sensitive applications or applications with a constrained error budget.

The LMP7732 comes in the 8-Pin SOIC and VSSOP packages. These small packages are ideal solutions for area constrained PC boards and portable electronics.

INPUT BIAS CURRENT CANCELLATION

The LMP7732 has proprietary input bias current cancellation circuitry on its input stage.

The LMP7732 has rail-to-rail input. This is achieved by having a p-input and n-input stage in parallel. [Figure 41](#) only shows one of the input stages as the circuitry is symmetrical for both stages.

[Figure 41](#) shows that as the common mode voltage gets closer to one of the extreme ends, current I_1 significantly increases. This increased current shows as an increase in voltage drop across resistor R_1 equal to $I_1 \cdot R_1$ on IN^+ of the amplifier. This voltage contributes to the offset voltage of the amplifier. When common mode voltage is in the mid-range, the transistors are operating in the linear region and I_1 is significantly small. The voltage drop due to I_1 across R_1 can be ignored as it is orders of magnitude smaller than the amplifier's input offset voltage. As the common mode voltage gets closer to one of the rails, the offset voltage generated due to I_1 increases and becomes comparable to the amplifiers offset voltage.

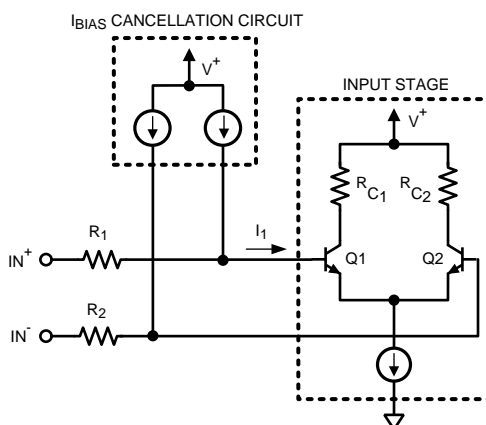


Figure 41. Input Bias Current Cancellation

INPUT VOLTAGE NOISE MEASUREMENT

The LMP7732 has very low input voltage noise. The peak-to-peak input voltage noise of the LMP7732 can be measured using the test circuit shown in Figure 42.

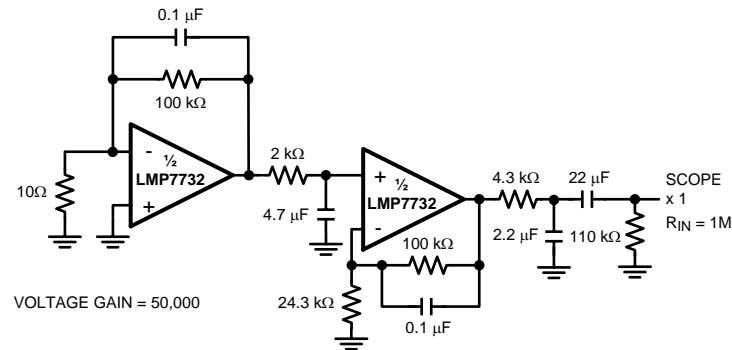


Figure 42. 0.1 Hz to 10 Hz Noise Test Circuit

The frequency response of this noise test circuit at the 0.1 Hz corner is defined by only one zero. The test time for the 0.1 Hz to 10 Hz noise measurement using this configuration should not exceed 10 seconds, as this time limit acts as an additional zero to reduce or eliminate the contributions of noise from frequencies below 0.1 Hz.

Figure 43 shows typical peak-to-peak noise for the LMP7732 measured with the circuit in Figure 42.

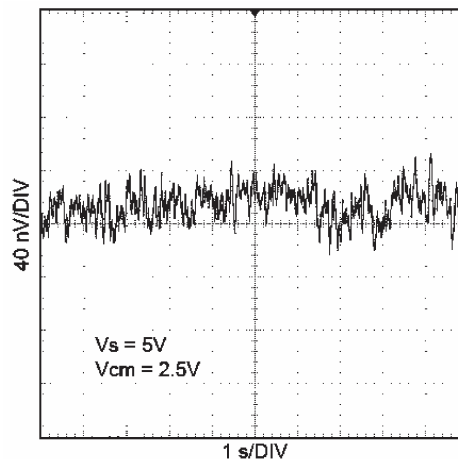


Figure 43. 0.1 Hz to 10 Hz Input Voltage Noise

Measuring the very low peak-to-peak noise performance of the LMP7732, requires special testing attention. In order to achieve accurate results, the device should be warmed up for at least five minutes. This is so that the input offset voltage of the op amp settles to a value. During this warm up period, the offset can typically change by a few μV because the chip temperature increases by about 30°C . If the 10 seconds of the measurement is selected to include this warm up time, some of this temperature change might show up as the measured noise. Figure 44 shows the start-up drift of five typical LMP7732 units.

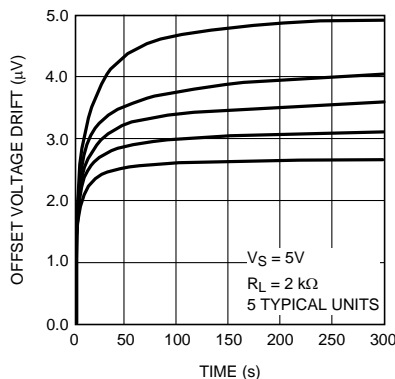


Figure 44. Start-Up Input Offset Voltage Drift

During the peak-to-peak noise measurement, the LMP7732 must be shielded. This prevents offset variations due to airflow. Offset can vary by a few nV due to this airflow and that can invalidate measurements of input voltage noise with a magnitude which is in the same range. For similar reasons, sudden motions must also be restricted in the vicinity of the test area. The feed-through which results from this motion could increase the observed noise value which in turn would invalidate the measurement.

DIODES BETWEEN THE INPUTS

The LMP7732 has a set of anti-parallel diodes between their input pins, as shown in Figure 45. These diodes are present to protect the input stage of the amplifiers. At the same time, they limit the amount of differential input voltage that is allowed on the input pins. A differential signal larger than the voltage needed to turn on the diodes might cause damage to the diodes. The differential voltage between the input pins should be limited to ± 20 mV or the input current needs to be limited to ± 20 mA.

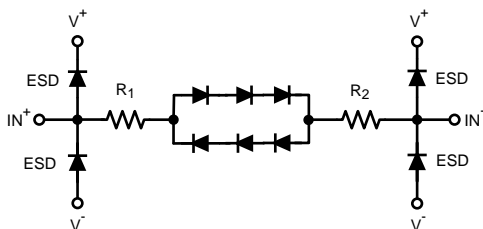


Figure 45. Anti-Parallel Diodes between Inputs

DRIVING AN ADC

Analog to Digital Converters, ADCs, usually have a sampling capacitor on their input. When the ADC's input is directly connected to the output of the amplifier a charging current flows from the amplifier to the ADC. This charging current causes a momentary glitch that can take some time to settle. There are different ways to minimize this effect. One way is to slow down the sampling rate. This method gives the amplifier sufficient time to stabilize its output. Another way to minimize the glitch, caused by the switch capacitor, is to have an external capacitor connected to the input of the ADC. This capacitor is chosen so that its value is much larger than the internal switching capacitor and it will hence provide the charge needed to quickly and smoothly charge the ADC's sampling capacitor. Since this large capacitor will be loading the output of the amplifier as well, an isolation resistor is needed between the output of the amplifier and this capacitor. The isolation resistor, R_{ISO} , separates the additional load capacitance from the output of the amplifier and will also form a low-pass filter and can be designed to provide noise reduction as well as anti-aliasing. The draw back of having R_{ISO} is that it reduces signal swing since there is some voltage drop across it.

Figure 46 (a) shows the ADC directly connected to the amplifier. To minimize the glitch in this setting, a slower sample rate needs to be used. Figure 46 (b) shows R_{ISO} and an external capacitor used to minimize the glitch.

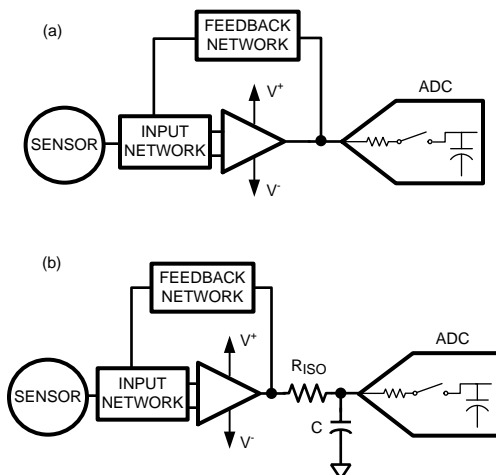


Figure 46. Driving An ADC

REVISION HISTORY

| Changes from Revision D (March 2013) to Revision E | Page |
|--|-----------------|
| <hr/> <ul style="list-style-type: none">• Changed layout of National Data Sheet to TI format | <hr/> 18 |

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) |
|---------------------------------|---------------|----------------------|-----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| LMP7732MA/NOPB | Active | Production | SOIC (D) 8 | 95 TUBE | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | LMP77 32MA |
| LMP7732MA/NOPB.A | Active | Production | SOIC (D) 8 | 95 TUBE | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | LMP77 32MA |
| LMP7732MAX/NOPB | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | LMP77 32MA |
| LMP7732MAX/NOPB.A | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | LMP77 32MA |
| LMP7732MM/NOPB | Active | Production | VSSOP (DGK) 8 | 1000 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | - | AZ3A |
| LMP7732MM/NOPB.A | Active | Production | VSSOP (DGK) 8 | 1000 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | AZ3A |
| LMP7732MM/NOPB.B | Active | Production | VSSOP (DGK) 8 | 1000 SMALL T&R | - | Call TI | Call TI | -40 to 125 | |
| LMP7732MME/NOPB | Active | Production | VSSOP (DGK) 8 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | - | AZ3A |
| LMP7732MME/NOPB.A | Active | Production | VSSOP (DGK) 8 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | AZ3A |
| LMP7732MME/NOPB.B | Active | Production | VSSOP (DGK) 8 | 250 SMALL T&R | - | Call TI | Call TI | -40 to 125 | |
| LMP7732MMX/NOPB | Active | Production | VSSOP (DGK) 8 | 3500 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | - | AZ3A |
| LMP7732MMX/NOPB.A | Active | Production | VSSOP (DGK) 8 | 3500 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | AZ3A |
| LMP7732MMX/NOPB.B | Active | Production | VSSOP (DGK) 8 | 3500 LARGE T&R | - | Call TI | Call TI | -40 to 125 | |

(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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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

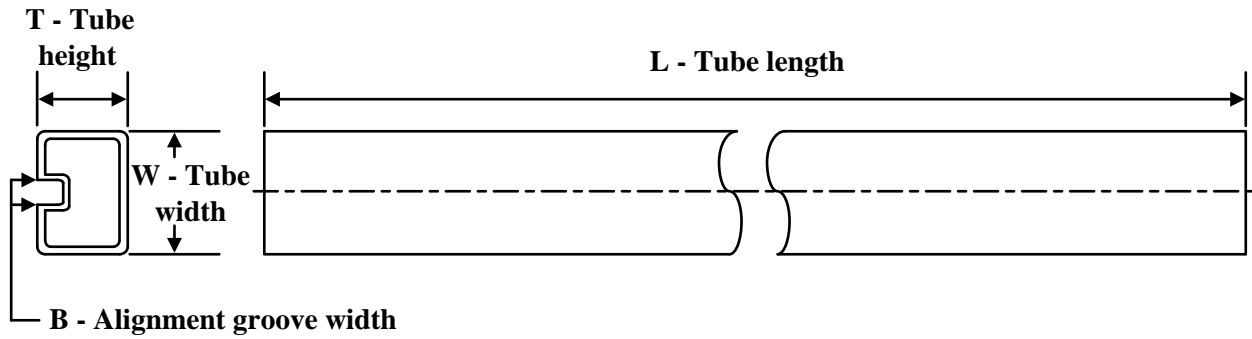
| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LMP7732MAX/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LMP7732MM/NOPB | VSSOP | DGK | 8 | 1000 | 177.8 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| LMP7732MME/NOPB | VSSOP | DGK | 8 | 250 | 177.8 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| LMP7732MMX/NOPB | VSSOP | DGK | 8 | 3500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 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) |
|-----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LMP7732MAX/NOPB | SOIC | D | 8 | 2500 | 356.0 | 356.0 | 35.0 |
| LMP7732MM/NOPB | VSSOP | DGK | 8 | 1000 | 208.0 | 191.0 | 35.0 |
| LMP7732MME/NOPB | VSSOP | DGK | 8 | 250 | 208.0 | 191.0 | 35.0 |
| LMP7732MMX/NOPB | VSSOP | DGK | 8 | 3500 | 356.0 | 356.0 | 35.0 |

TUBE


*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|------------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| LMP7732MA/NOPB | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LMP7732MA/NOPB.A | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |

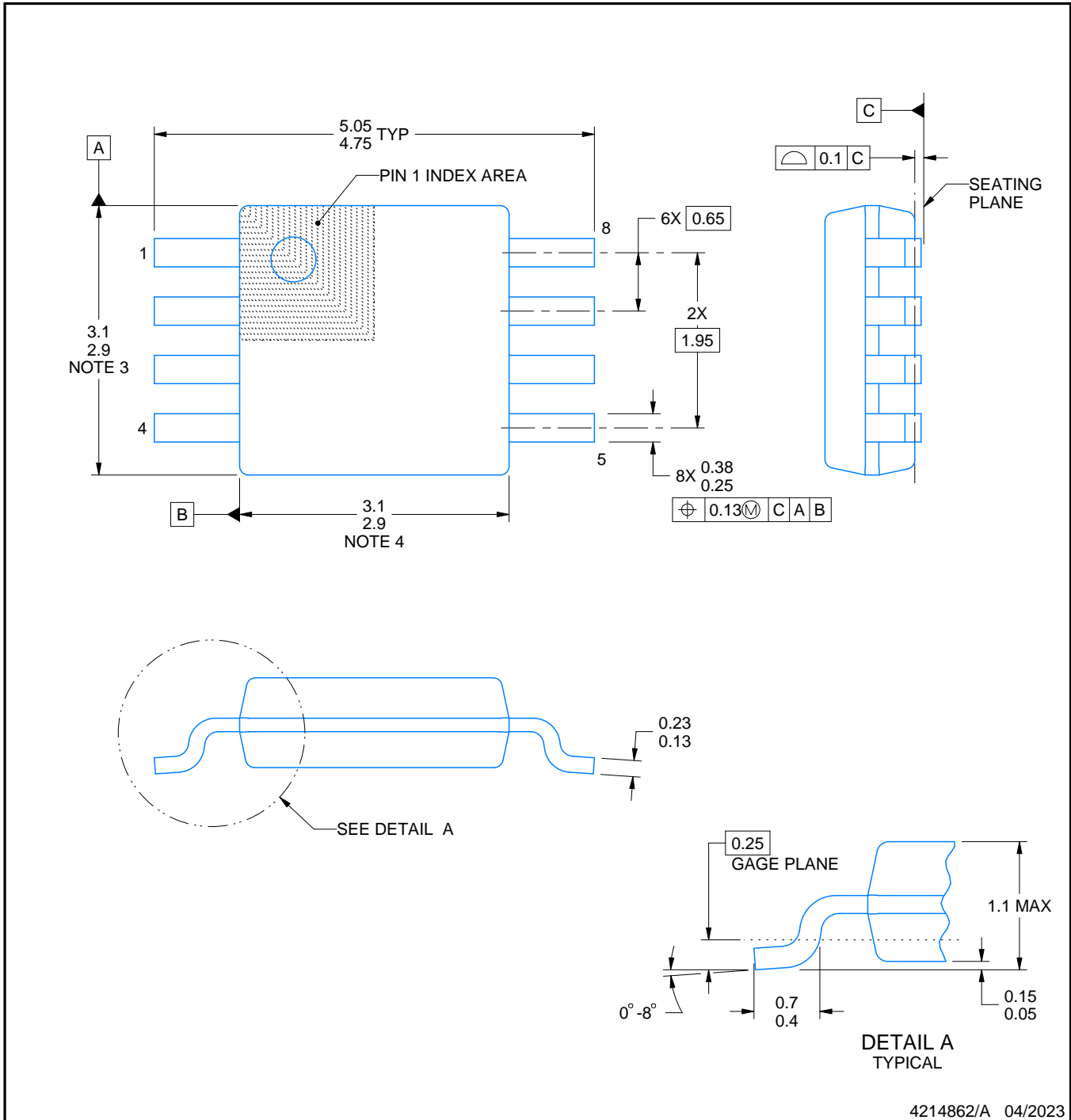
DGK0008A



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

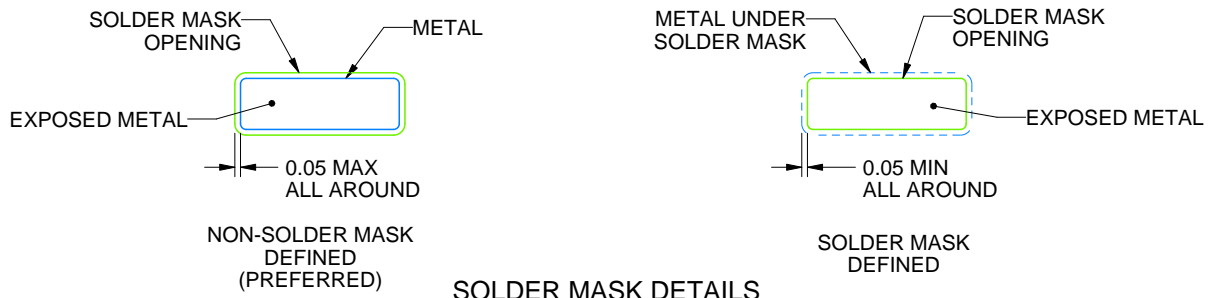
DGK0008A

™ VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X



SOLDER MASK DETAILS

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NOTES: (continued)

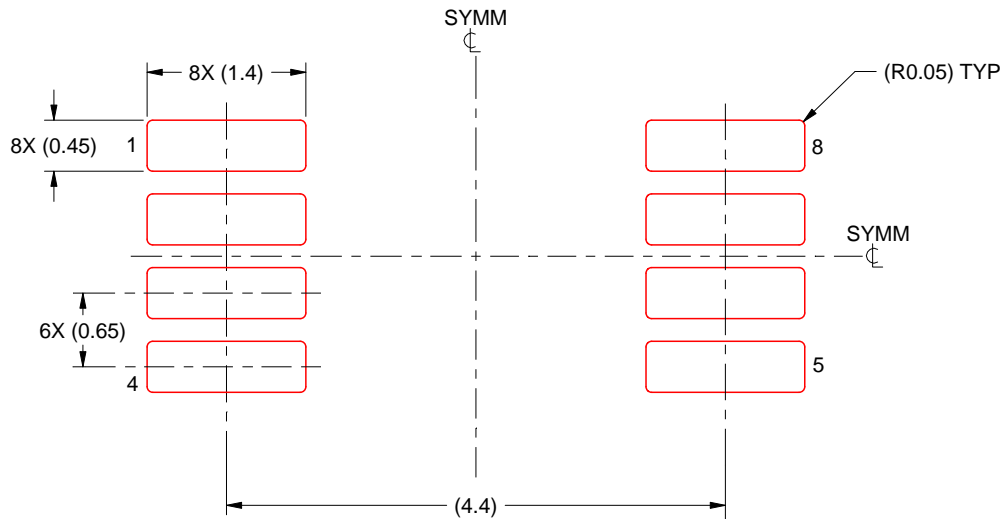
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It 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

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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.



D0008A

PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. 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 $.006$ [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

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

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

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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