

## LMH6609 900MHz Voltage Feedback Op Amp

Check for Samples: [LMH6609](#)

### FEATURES

- 900MHz –3dB bandwidth ( $A_V = 1$ )
- Large signal bandwidth and slew rate 100% tested
- 280MHz –3dB bandwidth ( $A_V = +2$ ,  $V_{OUT} = 2V_{PP}$ )
- 90mA linear output current
- 1400V/ $\mu$ s slew rate
- Unity gain stable
- <1mV input Offset voltage
- 7mA Supply current (no load)
- 6.6V to 12V supply voltage range
- 0.01%/0.026° differential gain/phase PAL
- 3.1nV/ $\sqrt{\text{Hz}}$  voltage noise
- Improved replacement for CLC440, CL420, CL426

### APPLICATIONS

- Test equipment
- IF/RF amplifier
- A/D Input driver
- Active filter
- Integrator
- DAC output buffer
- TI's Transimpedance amplifier

### DESCRIPTION

The LMH6609 is an ultra wideband, unity gain stable, low power, voltage feedback op amp that offers 900MHz bandwidth at a gain of 1, 1400V/ $\mu$ s slew rate and 90mA of linear output current.

The LMH6609 is designed with voltage feedback architecture for maximum flexibility especially for active filters and integrators. The LMH6609 has balanced, symmetrical inputs with well-matched bias currents and minimal offset voltage.

With Differential Gain of 0.01% and Differential Phase of 0.026° the LMH6609 is suited for video applications. The 90mA of linear output current makes the LMH6609 suitable for multiple video loads and cable driving applications as well.

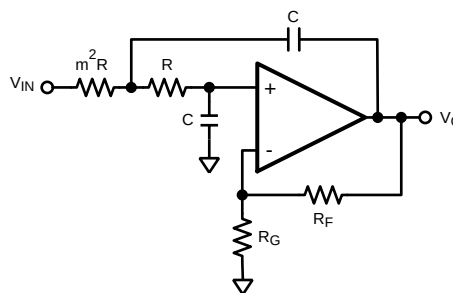
The supply voltage is specified at 6.6V and 10V. A low supply current of 7mA (at 10V supply) makes the LMH6609 useful in a wide variety of platforms, including portable or remote equipment that must run from battery power.

The LMH6609 is available in the industry standard 8-pin SOIC package and in the space-saving 5-pin SOT-23 package. The LMH6609 is specified for operation over the -40°C to +85°C temperature range. The LMH6609 is manufactured in state-of-the-art VIP10™ technology for high performance.

### Typical Application

$$K = 1 + \frac{R_F}{R_G} \quad Q = \frac{m}{1 + m^2(2 - K)} \quad \omega_0 = \frac{1}{mRC}$$

Q, K ARE UNITLESS.  
 $\omega_0$  IS RELATED TO BANDWIDTH AND IS IN UNITS OF RADIANS/SEC. DIVIDE  $\omega_0$  BY  $2\pi$  TO GET IT IN Hz.  
 REFER TO OA-26 FOR MORE INFORMATION.



**Figure 1. Sallen Key Low Pass Filter with Equal C Value**



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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 <sup>(1)</sup>

|                              |                                 |
|------------------------------|---------------------------------|
| $V_S$ ( $V^+ - V^-$ )        | $\pm 6.6V$                      |
| $I_{OUT}$                    | <sup>(2)</sup>                  |
| Common Mode Input Voltage    | $V^+$ to $V^-$                  |
| Maximum Junction Temperature | $+150^\circ C$                  |
| Storage Temperature Range    | $-65^\circ C$ to $+150^\circ C$ |
| Lead Temperature Range       | $+300^\circ C$                  |
| ESD Tolerance <sup>(3)</sup> |                                 |
| Human Body Model             | 2000V                           |
| Machine Model                | 200V                            |

- (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. For specifications, see the Electrical Characteristics tables.
- (2) The maximum output current ( $I_{OUT}$ ) is determined by device power dissipation limitations. See the Power Dissipation section of the Application Section for more details.
- (3) Human body model, 1.5k $\Omega$  in series with 100pF. Machine model, 0 $\Omega$  in series with 200pF.

## Operating Ratings <sup>(1)</sup>

| Thermal Resistance                    | Package     | $(\theta_{JC})$ | $(\theta_{JA})$ |
|---------------------------------------|-------------|-----------------|-----------------|
|                                       | 8-Pin SOIC  | $65^\circ C/W$  | $145^\circ C/W$ |
|                                       | 5-Pin SOT23 | $120^\circ C/W$ | $187^\circ C/W$ |
| Operating Temperature                 |             | $-40^\circ C$   | $+85^\circ C$   |
| Nominal Supply Voltage <sup>(2)</sup> |             | $\pm 3.3V$      | $\pm 6V$        |

- (1) The maximum output current ( $I_{OUT}$ ) is determined by device power dissipation limitations. See the Power Dissipation section of the Application Section for more details.
- (2) Nominal Supply voltage range is for supplies with regulation of 10% or better.

## $\pm 5V$ Electrical Characteristics

Unless specified,  $A_V = +2$ ,  $R_F = 250\Omega$ ;  $V_S = \pm 5V$ ,  $R_L = 100\Omega$ ; unless otherwise specified. **Boldface** limits apply over temperature Range. <sup>(1)</sup>

| Symbol                           | Parameter                | Conditions                  | Min  | Typ   | Max | Units      |
|----------------------------------|--------------------------|-----------------------------|------|-------|-----|------------|
| <b>Frequency Domain Response</b> |                          |                             |      |       |     |            |
| SSBW                             | -3dB Bandwidth           | $V_{OUT} = 0.5V_{PP}$       |      | 260   |     | MHz        |
| LSBW                             | -3dB Bandwidth           | $V_{OUT} = 4.0V_{PP}$       | 150  | 170   |     | MHz        |
| SSBWG1                           | -3dB Bandwidth $A_V = 1$ | $V_{OUT} = 0.25V_{PP}$      |      | 900   |     | MHz        |
| GFP                              | .1dB Bandwidth           | Gain is Flat to .1dB        |      | 130   |     | MHz        |
| DG                               | Differential Gain        | $R_L = 150\Omega$ , 4.43MHz |      | 0.01  |     | %          |
| DP                               | Differential Phase       | $R_L = 150\Omega$ , 4.43MHz |      | 0.026 |     | deg        |
| <b>Time Domain Response</b>      |                          |                             |      |       |     |            |
| TRS                              | Rise and Fall Time       | 1V Step                     |      | 1.6   |     | ns         |
| TRL                              |                          | 4V Step                     |      | 2.6   |     | ns         |
| $t_s$                            | Settling Time to 0.05%   | 2V Step                     |      | 15    |     | ns         |
| SR                               | Slew Rate                | 4V Step <sup>(2)</sup>      | 1200 | 1400  |     | V/ $\mu s$ |

- (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 specification of parametric performance is indicated in the electrical tables under conditions of internal self heating where  $T_J > T_A$ . See Applications Section for information on temperature derating of this device. Min/Max ratings are based on product characterization and simulation. Individual parameters are tested as noted.
- (2) Slew rate is Average of Rising and Falling 40-60% slew rates.

## ±5V Electrical Characteristics (continued)

Unless specified,  $A_V = +2$ ,  $R_F = 250\Omega$ ;  $V_S = \pm 5V$ ,  $R_L = 100\Omega$ ; unless otherwise specified. **Boldface** limits apply over temperature Range. <sup>(1)</sup>

| Symbol                               | Parameter                           | Conditions               | Min                 | Typ  | Max                 | Units           |
|--------------------------------------|-------------------------------------|--------------------------|---------------------|------|---------------------|-----------------|
| <b>Distortion and Noise Response</b> |                                     |                          |                     |      |                     |                 |
| HD2                                  | 2 <sup>nd</sup> Harmonic Distortion | $2V_{PP}$ , 20MHz        |                     | –63  |                     | dBc             |
| HD3                                  | 3 <sup>rd</sup> Harmonic Distortion | $2V_{PP}$ , 20MHz        |                     | –57  |                     | dBc             |
|                                      | Equivalent Input Noise              |                          |                     |      |                     |                 |
| VN                                   | Voltage Noise                       | >1MHz                    |                     | 3.1  |                     | nV/ $\sqrt{Hz}$ |
| CN                                   | Current Noise                       | >1MHz                    |                     | 1.6  |                     | pA/ $\sqrt{Hz}$ |
| <b>Static, DC Performance</b>        |                                     |                          |                     |      |                     |                 |
| $V_{IO}$                             | Input Offset Voltage                |                          |                     | ±0.8 | ±2.5<br><b>±3.5</b> | mV              |
|                                      | Input Voltage Temperature Drift     |                          |                     | 4    |                     | μV/°C           |
| $I_{BN}$                             | Input Bias Current                  |                          |                     | –2   | ±5<br><b>±8</b>     | μA              |
|                                      | Bias Current Temperature Drift      |                          |                     | 11   |                     | nA/°C           |
| $I_{BI}$                             | Input Offset Current                |                          |                     | 0.1  | ±1.5<br><b>±3</b>   | μA              |
| PSRR                                 | Power Supply Rejection Ratio        | DC, 1V Step              | 67<br><b>65</b>     | 73   |                     | dB              |
| CMRR                                 | Common Mode Rejection Ratio         | DC, 2V Step              | 67<br><b>65</b>     | 73   |                     | dB              |
| $I_{CC}$                             | Supply Current                      | $R_L = \infty$           |                     | 7.0  | 7.8<br><b>8.5</b>   | mA              |
| <b>Miscellaneous Performance</b>     |                                     |                          |                     |      |                     |                 |
| $R_{IN}$                             | Input Resistance                    |                          |                     | 1    |                     | MΩ              |
| $C_{IN}$                             | Input Capacitance                   |                          |                     | 1.2  |                     | pF              |
| $R_{OUT}$                            | Output Resistance                   | Closed Loop              |                     | 0.3  |                     | Ω               |
| $V_O$                                | Output Voltage Range                | $R_L = \infty$           | ±3.6<br><b>±3.3</b> | ±3.9 |                     | V               |
| $V_{OL}$                             |                                     | $R_L = 100\Omega$        | ±3.2<br><b>±3.0</b> | ±3.5 |                     | V               |
| CMIR                                 | Input Voltage Range                 | Common Mode, CMRR > 60dB | ±2.8<br><b>±2.5</b> | ±3.0 |                     | V               |
| $I_O$                                | Linear Output Current               | $V_{OUT}$                | ±60<br><b>±50</b>   | ±90  |                     | mA              |

### ±3.3V Electrical Characteristics

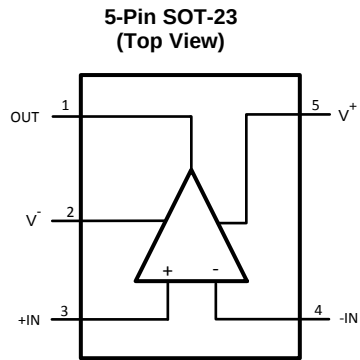
Unless specified,  $A_V = +2$ ,  $R_F = 250\Omega$ ;  $V_S = \pm 3.3V$ ,  $R_L = 100\Omega$ ; unless otherwise specified. **Boldface** limits apply over temperature range. <sup>(1)</sup>

| Symbol                               | Parameter                           | Conditions                  | Min       | Typ       | Max                                      | Units                  |
|--------------------------------------|-------------------------------------|-----------------------------|-----------|-----------|------------------------------------------|------------------------|
| <b>Frequency Domain Response</b>     |                                     |                             |           |           |                                          |                        |
| SSBW                                 | –3dB Bandwidth                      | $V_{OUT} = 0.5V_{PP}$       |           | 180       |                                          | MHz                    |
| LSBW                                 | –3dB Bandwidth                      | $V_{OUT} = 3.0V_{PP}$       |           | 110       |                                          | MHz                    |
| SSBWG1                               | –3dB Bandwidth $A_V = 1$            | $V_{OUT} = 0.25V_{PP}$      |           | 450       |                                          | MHz                    |
| GFP                                  | .1dB Bandwidth                      | $V_{OUT} = 1V_{PP}$         |           | 40        |                                          | MHz                    |
| DG                                   | Differential Gain                   | $R_L = 150\Omega$ , 4.43MHz |           | .01       |                                          | %                      |
| DP                                   | Differential Phase                  | $R_L = 150\Omega$ , 4.43MHz |           | .06       |                                          | deg                    |
| <b>Time Domain Response</b>          |                                     |                             |           |           |                                          |                        |
| TRL                                  |                                     | 1V Step                     |           | 2.2       |                                          | ns                     |
| SR                                   | Slew Rate                           | 2V Step <sup>(2)</sup>      |           | 800       |                                          | V/ $\mu$ s             |
| <b>Distortion and Noise Response</b> |                                     |                             |           |           |                                          |                        |
| HD2                                  | 2 <sup>nd</sup> Harmonic Distortion | $2V_{PP}$ , 20MHz           |           | –63       |                                          | dBc                    |
| HD3                                  | 3 <sup>rd</sup> Harmonic Distortion | $2V_{PP}$ , 20MHz           |           | –43       |                                          | dBc                    |
|                                      | Equivalent Input Noise              |                             |           |           |                                          |                        |
| VN                                   | Voltage Noise                       | >1MHz                       |           | 3.7       |                                          | nV/ $\sqrt{\text{Hz}}$ |
| CN                                   | Current Noise                       | >1MHz                       |           | 1.1       |                                          | pA/ $\sqrt{\text{Hz}}$ |
| <b>Static, DC Performance</b>        |                                     |                             |           |           |                                          |                        |
| $V_{IO}$                             | Input Offset Voltage                |                             |           | 0.8       | $\pm 2.5$<br><b><math>\pm 3.5</math></b> | mV                     |
| $I_{BN}$                             | Input Bias Current                  |                             |           | –1        | $\pm 3$<br><b><math>\pm 6</math></b>     | $\mu$ A                |
| $I_{BI}$                             | Input Offset Current                |                             |           | 0         | $\pm 1.5$<br><b><math>\pm 3</math></b>   | $\mu$ A                |
| PSRR                                 | Power Supply Rejection Ratio        | DC, .5V Step                | 67        | 73        |                                          | dB                     |
| CMRR                                 | Common Mode Rejection Ratio         | DC, 1V Step                 | 67        | 75        |                                          | dB                     |
| $I_{CC}$                             | Supply Current                      | $R_L = \infty$              |           | 3.6       | 5<br><b>6</b>                            | mA                     |
| <b>Miscellaneous Performance</b>     |                                     |                             |           |           |                                          |                        |
| $R_{OUT}$                            | Input Resistance                    | Close Loop                  |           | .05       |                                          | $\Omega$               |
| $V_O$                                | Output Voltage Range                | $R_L = \infty$              | $\pm 2.1$ | $\pm 2.3$ |                                          | V                      |
| $V_{OL}$                             |                                     | $R_L = 100\Omega$           | $\pm 1.9$ | $\pm 2.0$ |                                          | V                      |
| CMIR                                 | Input Voltage Range                 | Common Mode                 |           | $\pm 1.3$ |                                          | V                      |
| $I_O$                                | Linear Output Current               | $V_{OUT}$                   | $\pm 30$  | $\pm 45$  |                                          | mA                     |

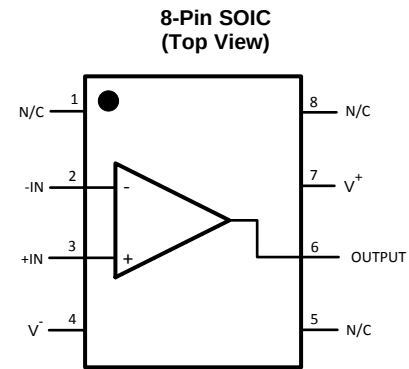
- (1) Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that  $T_J = T_A$ . No specification of parametric performance is indicated in the electrical tables under conditions of internal self heating where  $T_J > T_A$ . See Applications Section for information on temperature derating of this device. Min/Max ratings are based on product characterization and simulation. Individual parameters are tested as noted.

- (2) Slew rate is Average of Rising and Falling 40-60% slew rates.

## CONNECTION DIAGRAM



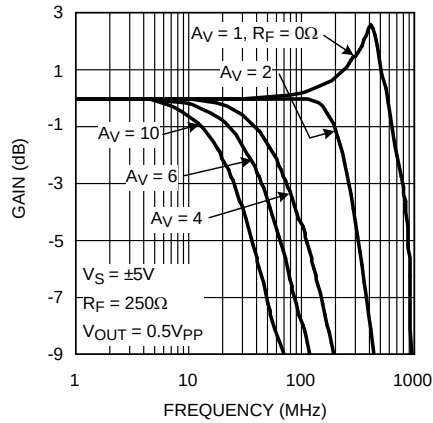
See Package Number D0008A



See Package Number DBV0005A

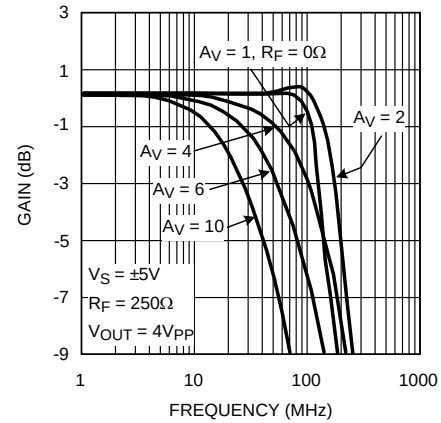
## Typical Performance Characteristics

**Small Signal Non-Inverting Frequency Response**



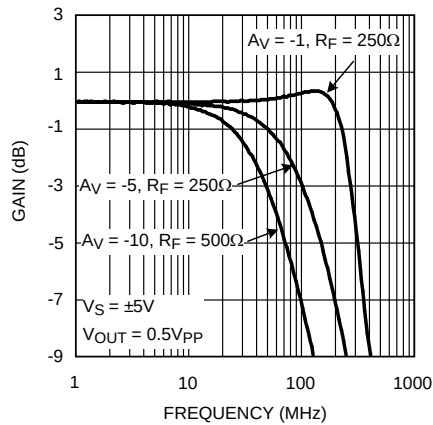
**Figure 2.**

**Large Signal Non-Inverting Frequency Response**



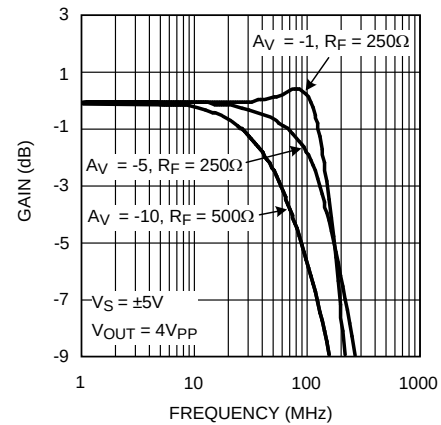
**Figure 3.**

**Small Signal Inverting Frequency Response**



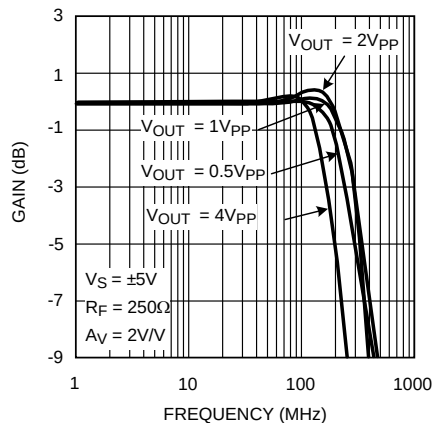
**Figure 4.**

**Large Signal Inverting Frequency Response**



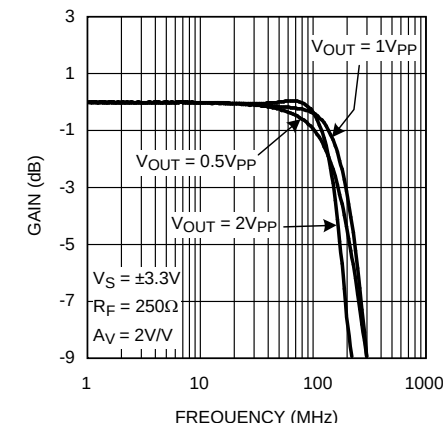
**Figure 5.**

**Frequency Response  
vs.  
 $V_{OUT} A_V = 2$**



**Figure 6.**

**Frequency Response  
vs.  
 $V_{OUT} A_V = 2$**



**Figure 7.**

## Typical Performance Characteristics (continued)

### Frequency Response

vs.  
 $V_{OUT} A_V = 1$

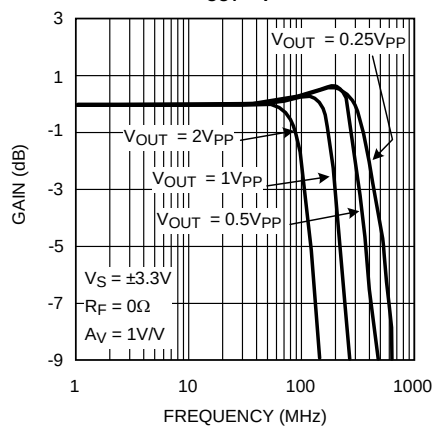


Figure 8.

### Frequency Response

vs.  
 $V_{OUT} A_V = -1$

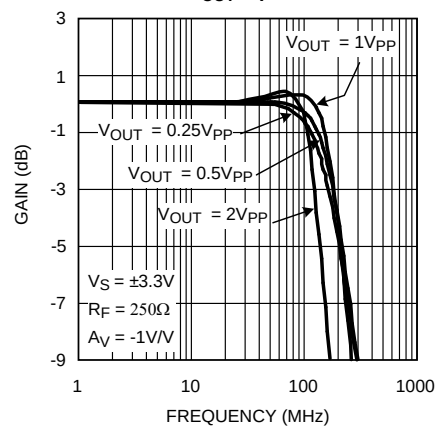


Figure 9.

### Frequency Response

vs.  
 $V_{OUT} A_V = -1$

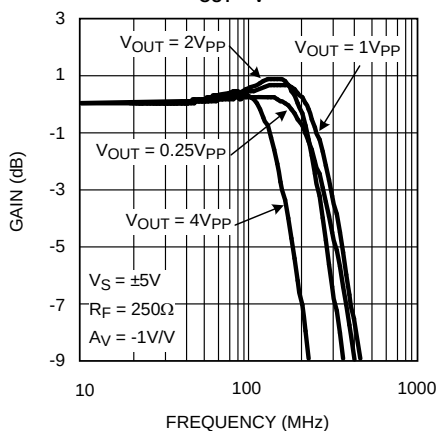


Figure 10.

### Frequency Response

vs.  
Cap Load

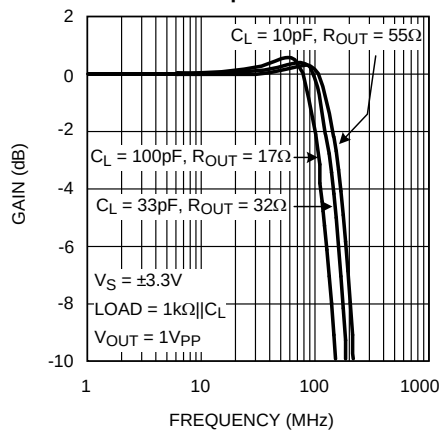


Figure 11.

### Frequency Response

vs.  
Cap Load

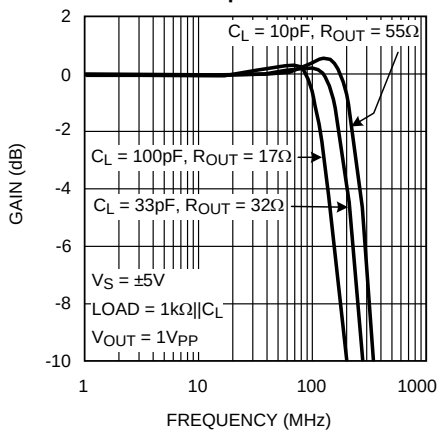


Figure 12.

### Suggested R\_OUT

vs.  
Cap Load

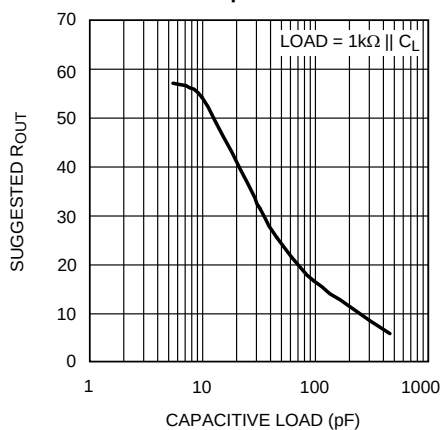


Figure 13.

## Typical Performance Characteristics (continued)

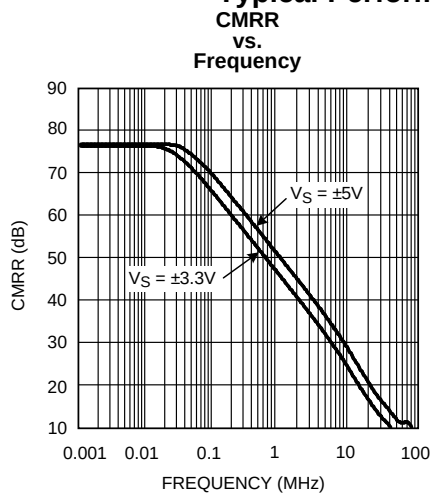


Figure 14.

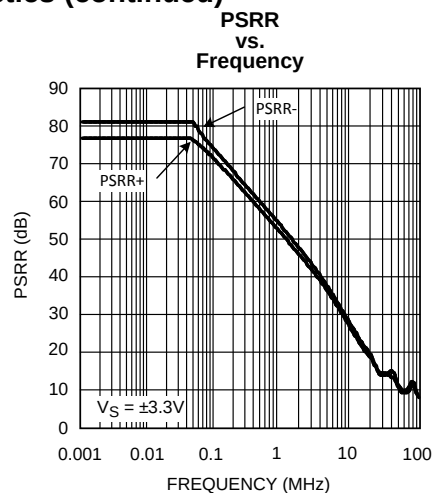


Figure 15.

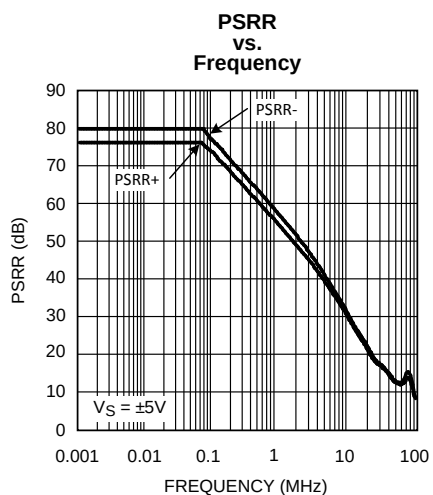


Figure 16.

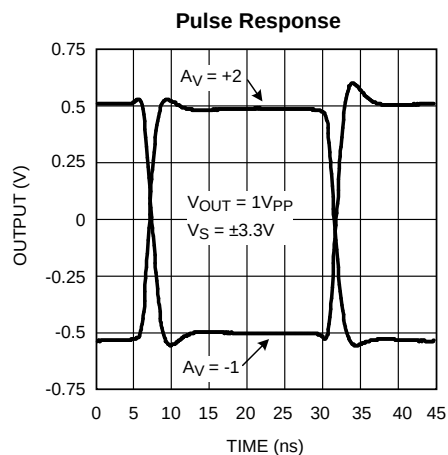


Figure 17.

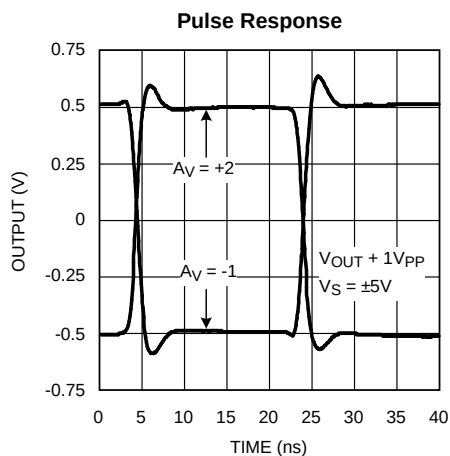


Figure 18.

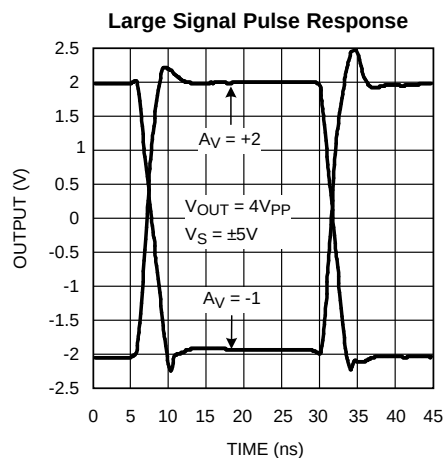


Figure 19.



## Typical Performance Characteristics (continued)

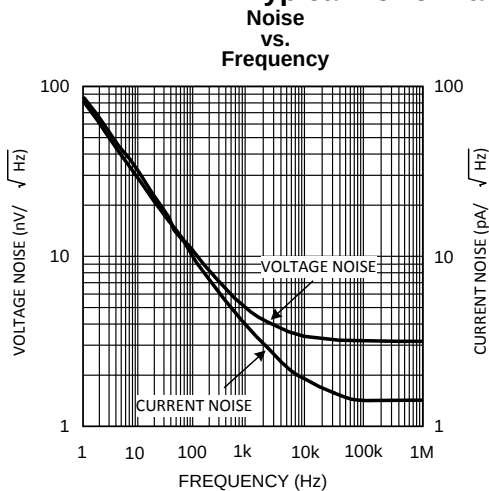


Figure 20.

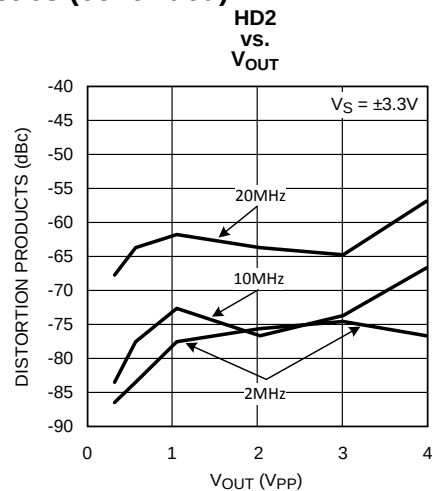


Figure 21.

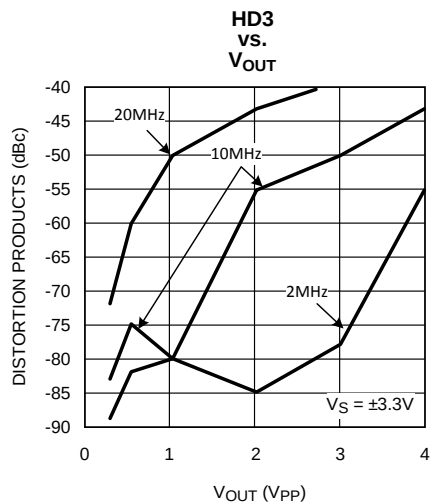


Figure 22.

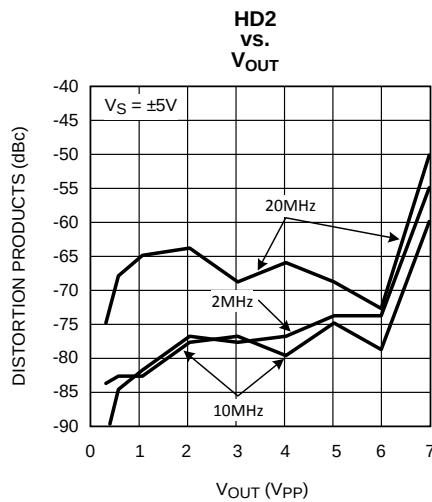


Figure 23.

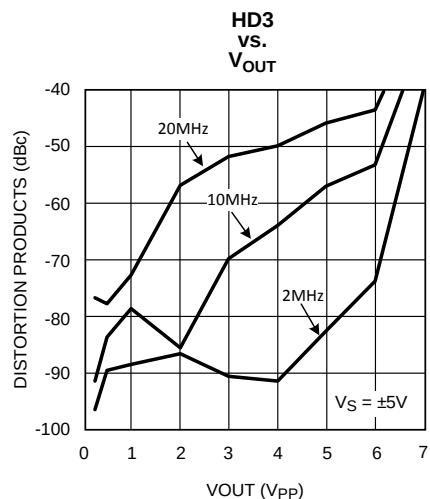


Figure 24.

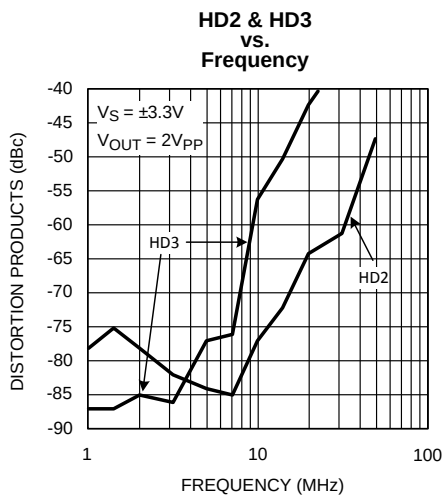


Figure 25.

## Typical Performance Characteristics (continued)

HD2 & HD3  
vs.  
Frequency

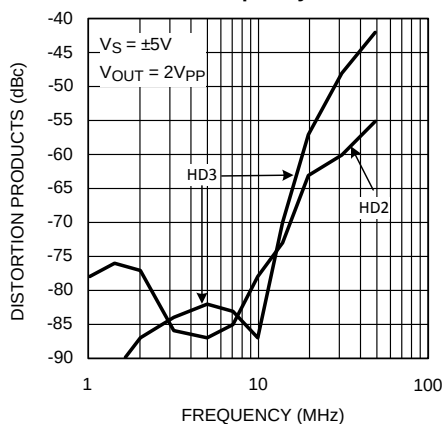


Figure 26.

### Differential Gain & Phase

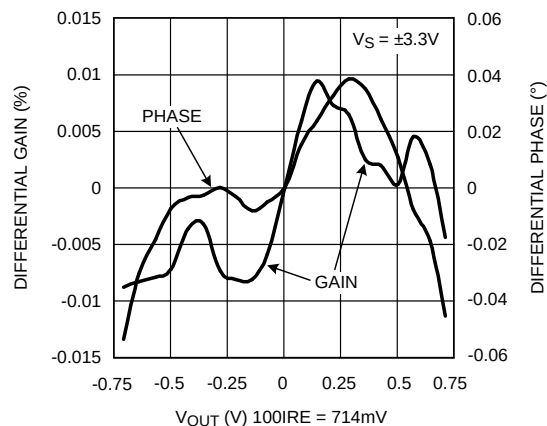


Figure 27.

### Differential Gain & Phase

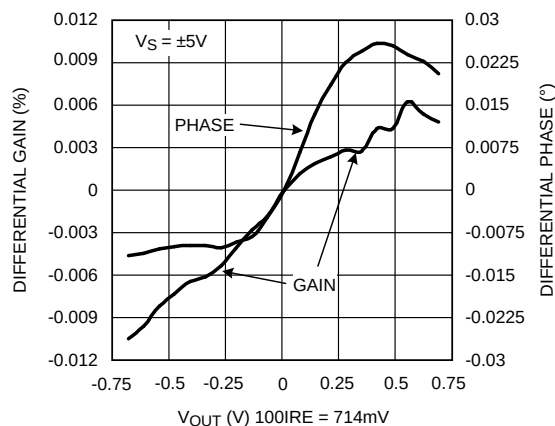


Figure 28.

### Open Loop Gain & Phase

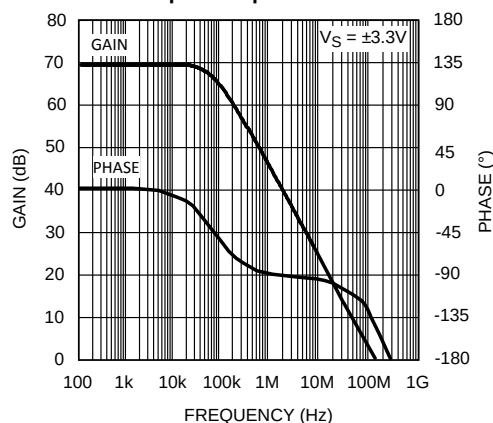


Figure 29.

### Open Loop Gain & Phase

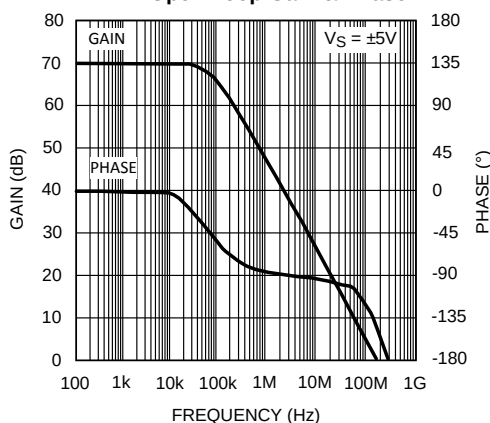


Figure 30.

### Closed Loop Output Resistance

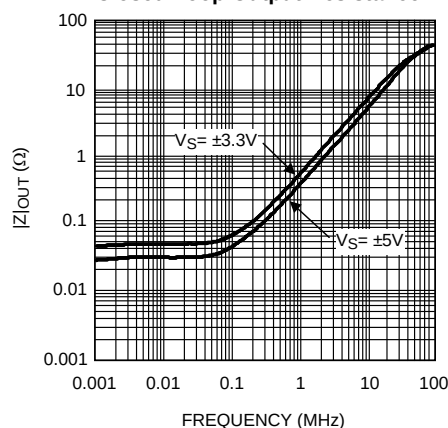


Figure 31.

## APPLICATION INFORMATION

### GENERAL DESIGN EQUATION

The LMH6609 is a unity gain stable voltage feedback amplifier. The matched input bias currents track well over temperature. This allows the DC offset to be minimized by matching the impedance seen by both inputs.

### GAIN

The non-inverting and inverting gain equations for the LMH6609 are as follows:

$$\text{NON-INVERTING GAIN : } 1 + \frac{R_F}{R_G}$$

$$\text{INVERTING GAIN : } - \frac{R_F}{R_G}$$

(1)

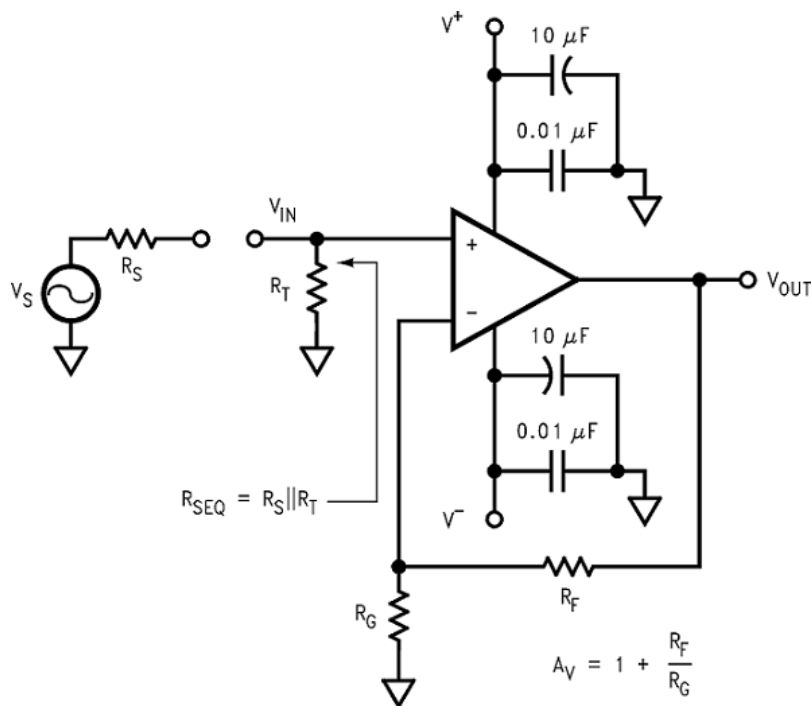


Figure 32. Typical Non-Inverting Application

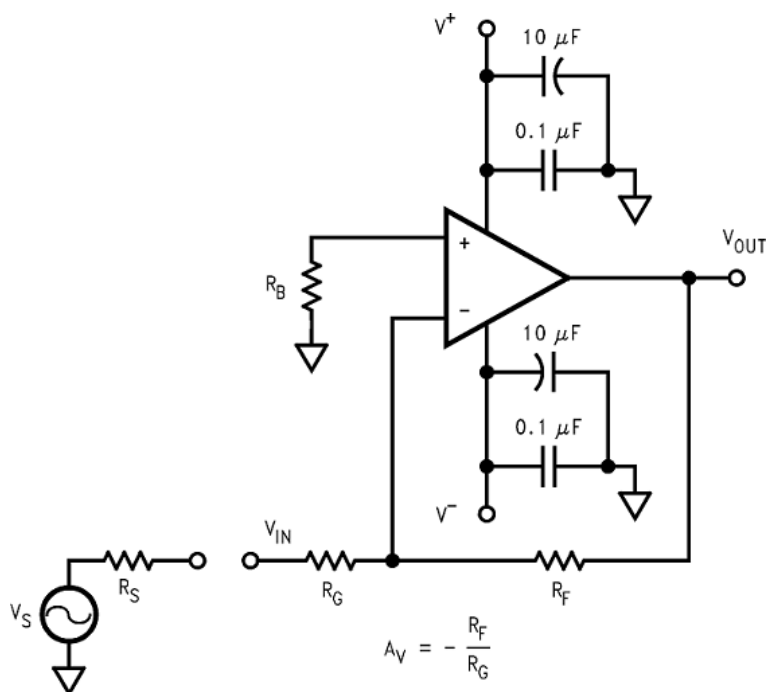


Figure 33. Typical Inverting Application

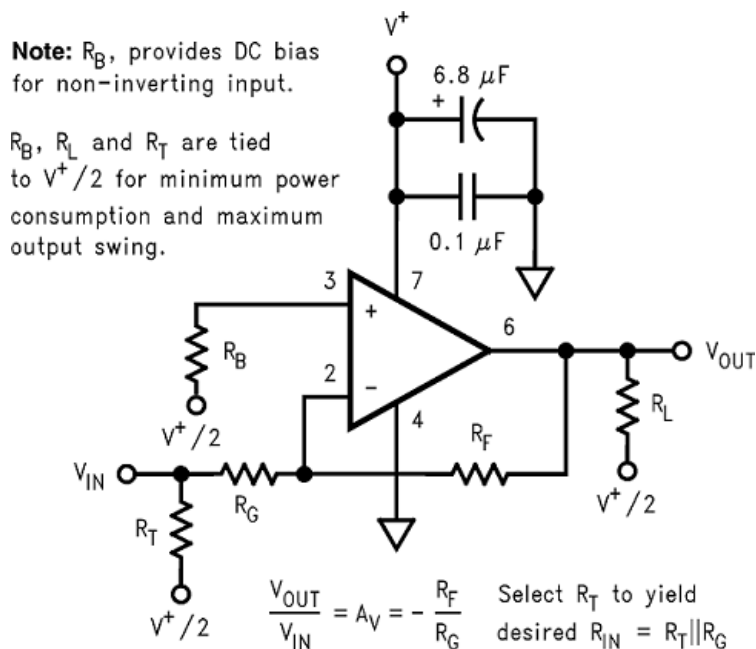


Figure 34. Single Supply Inverting

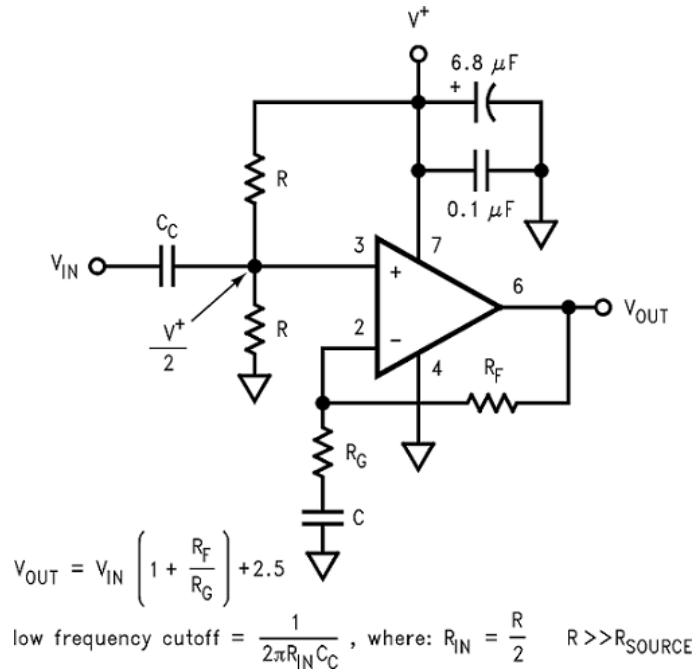


Figure 35. AC Coupled Non-Inverting

## GAIN BANDWIDTH PRODUCT

The LMH6609 is a voltage feedback amplifier, whose closed-loop bandwidth is approximately equal to the gain-bandwidth product (GBP) divided by the gain ( $A_V$ ). For gains greater than 5,  $A_V$  sets the closed-loop bandwidth of the LMH6609.

$$\text{CLOSED LOOP BANDWIDTH} = \frac{\text{GBP}}{A_V}$$

$$A_V = \frac{(R_F + R_G)}{R_G}$$

$$\text{GBP} = 240\text{MHz}$$

(2)

For Gains less than 5, refer to the frequency response plots to determine maximum bandwidth. For large signal bandwidth the slew rate is a more accurate predictor of bandwidth.

$$f_{MAX} = \frac{S_R}{2\pi V_P}$$

(3)

Where  $f_{MAX}$  = bandwidth,  $S_R$  = Slew rate and  $V_P$  = peak amplitude.

## OUTPUT DRIVE AND SETTLING TIME PERFORMANCE

The LMH6609 has large output current capability. The 100mA of output current makes the LMH6609 an excellent choice for applications such as:

- Video Line Drivers
- Distribution Amplifiers

When driving a capacitive load or coaxial cable, include a series resistance  $R_{OUT}$  to back match or improve settling time. Refer to the Driving Capacitive Loads section for guidance on selecting an output resistor for driving capacitive loads.

## EVALUATION BOARDS

TI offers the following evaluation boards as a guide for high frequency layout and as an aid in device testing and characterization. Many of the data sheet plots were measured with these boards.

| Device    | Package | Board Part # |
|-----------|---------|--------------|
| LMH6609MA | SOIC    | LMH730227    |
| LMH6609MF | SOT-23  | LMH730216    |

## CIRCUIT LAYOUT CONSIDERATION

A proper printed circuit layout is essential for achieving high frequency performance. TI provides evaluation boards for the LMH6609 as shown above. These boards were laid out for optimum, high-speed performance. The ground plane was removed near the input and output pins to reduce parasitic capacitance. Also, all trace lengths were minimized to reduce series inductances.

Supply bypassing is required for the amplifiers performance. The bypass capacitors provide a low impedance return current path at the supply pins. They also provide high frequency filtering on the power supply traces. 10 $\mu$ F tantalum and .01 $\mu$ F capacitors are recommended on both supplies (from supply to ground). In addition, a 0.1 $\mu$ F ceramic capacitor can be added from  $V^+$  to  $V^-$  to aid in second harmonic suppression.

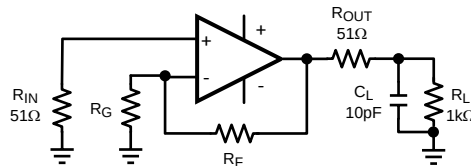


Figure 36. Driving Capacitive Loads with  $R_{OUT}$  for Improved Stability

## DRIVING CAPACITIVE LOADS

Capacitive output loading applications will benefit from the use of a series output resistor  $R_{OUT}$ . Figure 36 shows the use of a series output resistor,  $R_{OUT}$  as it might be applied when driving an analog to digital converter. The charts "Suggested  $R_O$  vs. Cap Load" in the Typical Performance Section give a recommended value for mitigating capacitive loads. The values suggested in the charts are selected for .5dB or less of peaking in the frequency response. This gives a good compromise between settling time and bandwidth. For applications where maximum frequency response is needed and some peaking is tolerable, the value of  $R_O$  can be reduced slightly from the recommended values. There will be amplitude lost in the series resistor unless the gain is adjusted to compensate; this effect is most noticeable with heavy resistive loads.

## COMPONENT SELECTION AND FEEDBACK RESISTOR

Surface mount components are highly recommended for the LMH6609. Leaded components will introduce unpredictable parasitic loading that will interfere with proper device operation. Do not use wire wound resistors.

The LMH6609 operates best with a feedback resistor of approximately 250Ω for all gains of +2 and greater and for –1 and less. With lower gains in particular, large value feedback resistors will exaggerate the effects of parasitic capacitances and may lead to ringing on the pulse response and frequency response peaking. Large value resistors also add undesirable thermal noise. Feedback resistors that are much below 100Ω will load the output stage, which will reduce voltage output swing, increase device power dissipation, increase distortion and reduce current available for driving the load.

In the buffer configuration the output should be shorted directly to the inverting input. This feedback does not load the output stage because the inverting input is a high impedance point and there is no gain set resistor to ground.

## OPTIMIZING DC ACCURACY

The LMH6609 offers excellent DC accuracy. The well-matched inputs of this amplifier allows even better performance if care is taken to balance the impedances seen by the two inputs. The parallel combination of the gain setting  $R_G$  and feedback  $R_F$  resistors should be equal to  $R_{SEQ}$ , the resistance of the source driving the op amp in parallel with any terminating Resistor (See [Figure 32](#)). Combining this with the non inverting gain equation gives the following parameters:

$$R_F = A_{VRSEQ}$$

$$R_G = R_F / (A_V - 1)$$

For Inverting gains the bias current cancellation is accomplished by placing a resistor  $R_B$  on the non-inverting input equal in value to the resistance seen by the inverting input (See [Figure 33](#)).  $R_B = R_F \parallel (R_G + R_S)$

The additional noise contribution of  $R_B$  can be minimized by the use of a shunt capacitor (not shown).

## POWER DISSIPATION

The LMH6609 has the ability to drive large currents into low impedance loads. Some combinations of ambient temperature and device loading could result in device overheating. For most conditions peak power values are not as important as RMS powers. To determine the maximum allowable power dissipation for the LMH6609 use the following formula:

$$P_{MAX} = (150^\circ - T_{AMB}) / \theta_{JA} \quad (4)$$

Where  $T_{AMB}$  = Ambient temperature (°C) and  $\theta_{JA}$  = Thermal resistance, from junction to ambient, for a given package (°C/W). For the SOIC package  $\theta_{JA}$  is 148°C/W, for the SOT-23 it is 250°C/W. 150°C is the absolute maximum limit for the internal temperature of the device.

Either forced air cooling or a heat sink can greatly increase the power handling capability for the LMH6609.

## VIDEO PERFORMANCE

The LMH6609 has been designed to provide good performance with both PAL and NTSC composite video signals. The LMH6609 is specified for PAL signals. NTSC performance is typically marginally better due to the lower frequency content of the signal. Performance degrades as the loading is increased, therefore best performance will be obtained with back-terminated loads. The back termination reduces reflections from the transmission line and effectively masks transmission line and other parasitic capacitances from the amplifier output stage. This means that the device should be configured for a gain of 2 in order to have a net gain of 1 after the terminating resistor. (See [Figure 37](#))

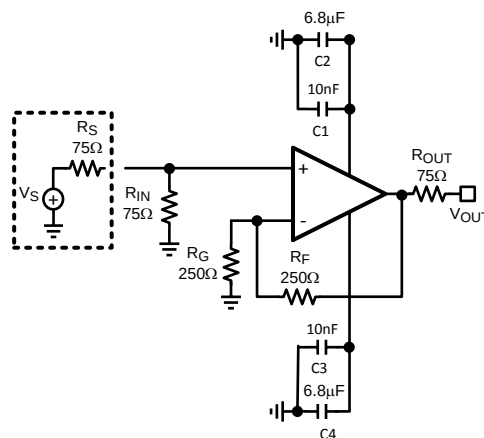


Figure 37. Typical Video Application

## ESD PROTECTION

The LMH6609 is protected against electrostatic discharge (ESD) on all pins. The LMH6609 will survive 2000V Human Body model or 200V Machine model events.

Under closed loop operation the ESD diodes have no effect on circuit performance. There are occasions, however, when the ESD diodes may be evident. For instance, if the amplifier is powered down and a large input signal is applied the ESD diodes will conduct.

## TRANSIMPEDANCE AMPLIFIER

The low input current noise and unity gain stability of the LMH6609 make it an excellent choice for transimpedance applications. Figure 38 illustrates a low noise transimpedance amplifier that is commonly implemented with photo diodes.  $R_F$  sets the transimpedance gain. The photo diode current multiplied by  $R_F$  determines the output voltage.

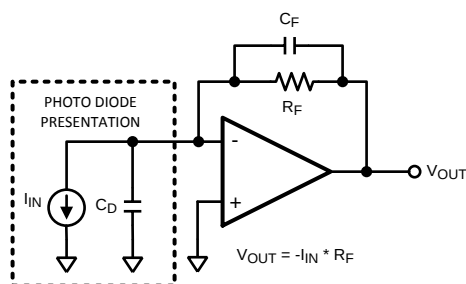


Figure 38. Transimpedance Amplifier

The capacitances are defined as:

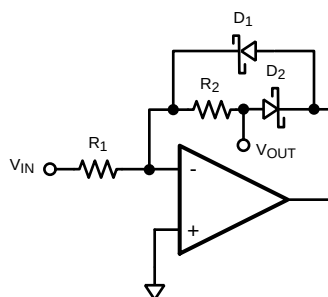
- $C_D$  = Equivalent Diode Capacitance
- $C_F$  = Feedback Capacitance

The feedback capacitor is used to give optimum flatness and stability. As a starting point the feedback capacitance should be chosen as  $\frac{1}{2}$  of the Diode capacitance. Lower feedback capacitors will peak frequency response.



## Rectifier

The large bandwidth of the LMH6609 allows for high-speed rectification. A common rectifier topology is shown in Figure 39.  $R_1$  and  $R_2$  set the gain of the rectifier.



**Figure 39. Rectifier Topology**

## REVISION HISTORY

### Changes from Revision E (March 2013) to Revision F

### Page

- Changed layout of National Data Sheet to TI format ..... [17](#)

## PACKAGING INFORMATION

| Orderable part number           | Status<br>(1) | Material type<br>(2) | Package   Pins   | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|---------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| LMH6609 MDC                     | Active        | Production           | DIESALE (Y)   0  | 400   NOT REQUIRED    | Yes         | Call TI                              | Level-1-NA-UNLIM                  | -40 to 85    |                     |
| LMH6609-MDC.A                   | Active        | Production           | DIESALE (Y)   0  | 400   NOT REQUIRED    | Yes         | Call TI                              | Level-1-NA-UNLIM                  | -40 to 85    |                     |
| <a href="#">LMH6609MA/NOPB</a>  | Active        | Production           | SOIC (D)   8     | 95   TUBE             | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | LMH66<br>09MA       |
| LMH6609MA/NOPB.A                | Active        | Production           | SOIC (D)   8     | 95   TUBE             | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | LMH66<br>09MA       |
| <a href="#">LMH6609MAX/NOPB</a> | Active        | Production           | SOIC (D)   8     | 2500   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | LMH66<br>09MA       |
| LMH6609MAX/NOPB.A               | Active        | Production           | SOIC (D)   8     | 2500   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | LMH66<br>09MA       |
| <a href="#">LMH6609MF/NOPB</a>  | Active        | Production           | SOT-23 (DBV)   5 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | A89A                |
| LMH6609MF/NOPB.A                | Active        | Production           | SOT-23 (DBV)   5 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | A89A                |
| <a href="#">LMH6609MFX/NOPB</a> | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | A89A                |
| LMH6609MFX/NOPB.A               | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | A89A                |

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

<sup>(2)</sup> **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.

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

<sup>(4)</sup> **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.

<sup>(5)</sup> **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.

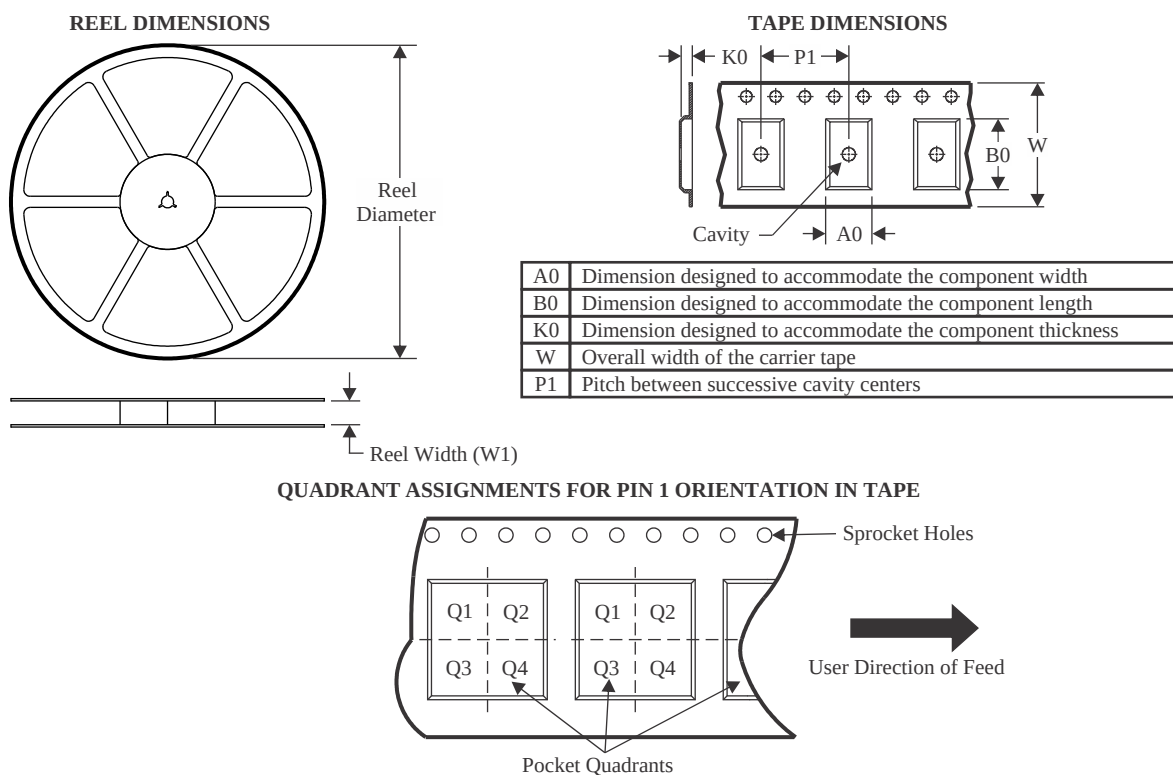
<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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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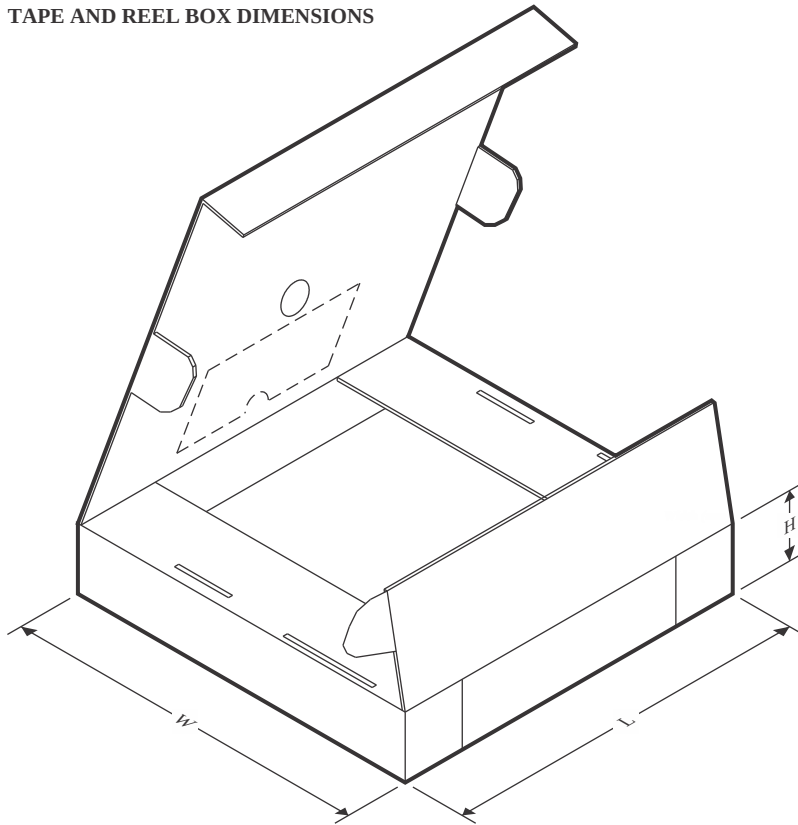
## TAPE AND REEL INFORMATION



\*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 |
|-----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LMH6609MAX/NOPB | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.5     | 5.4     | 2.0     | 8.0     | 12.0   | Q1            |
| LMH6609MF/NOPB  | SOT-23       | DBV             | 5    | 1000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LMH6609MFX/NOPB | SOT-23       | DBV             | 5    | 3000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |

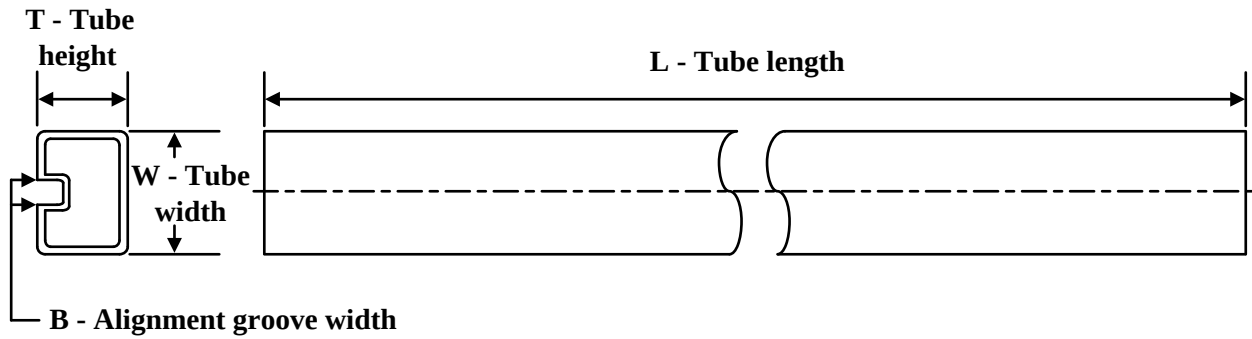
## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device          | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LMH6609MAX/NOPB | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |
| LMH6609MF/NOPB  | SOT-23       | DBV             | 5    | 1000 | 208.0       | 191.0      | 35.0        |
| LMH6609MFX/NOPB | SOT-23       | DBV             | 5    | 3000 | 208.0       | 191.0      | 35.0        |

## TUBE



\*All dimensions are nominal

| Device           | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|------------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| LMH6609MA/NOPB   | D            | SOIC         | 8    | 95  | 495    | 8      | 4064   | 3.05   |
| LMH6609MA/NOPB.A | D            | SOIC         | 8    | 95  | 495    | 8      | 4064   | 3.05   |



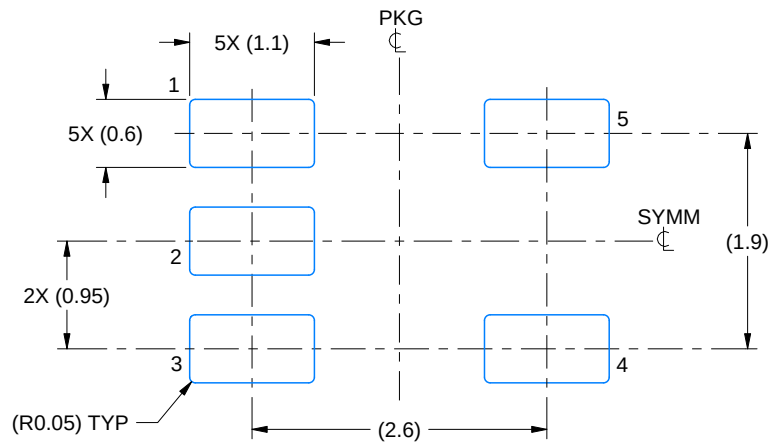


# EXAMPLE BOARD LAYOUT

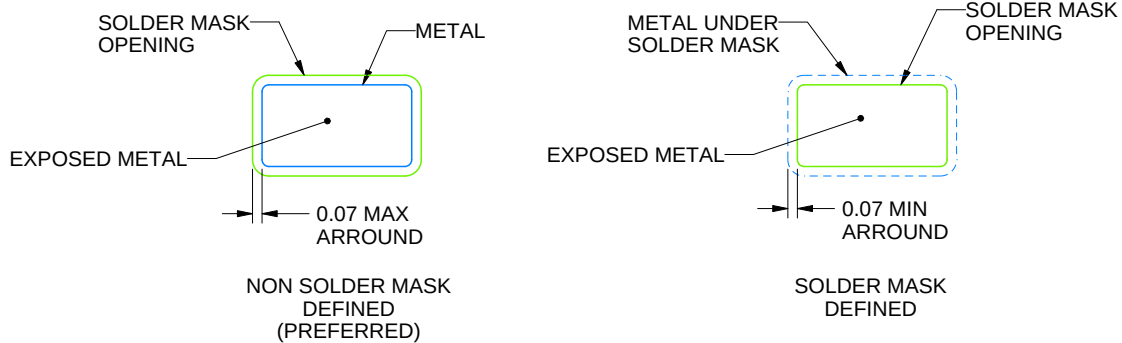
DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:15X



SOLDER MASK DETAILS

4214839/K 08/2024

NOTES: (continued)

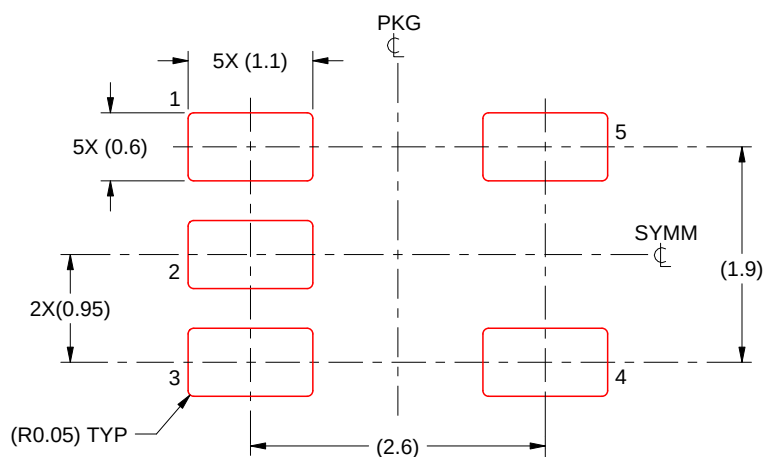
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR

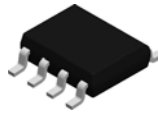


SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:15X

4214839/K 08/2024

NOTES: (continued)

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

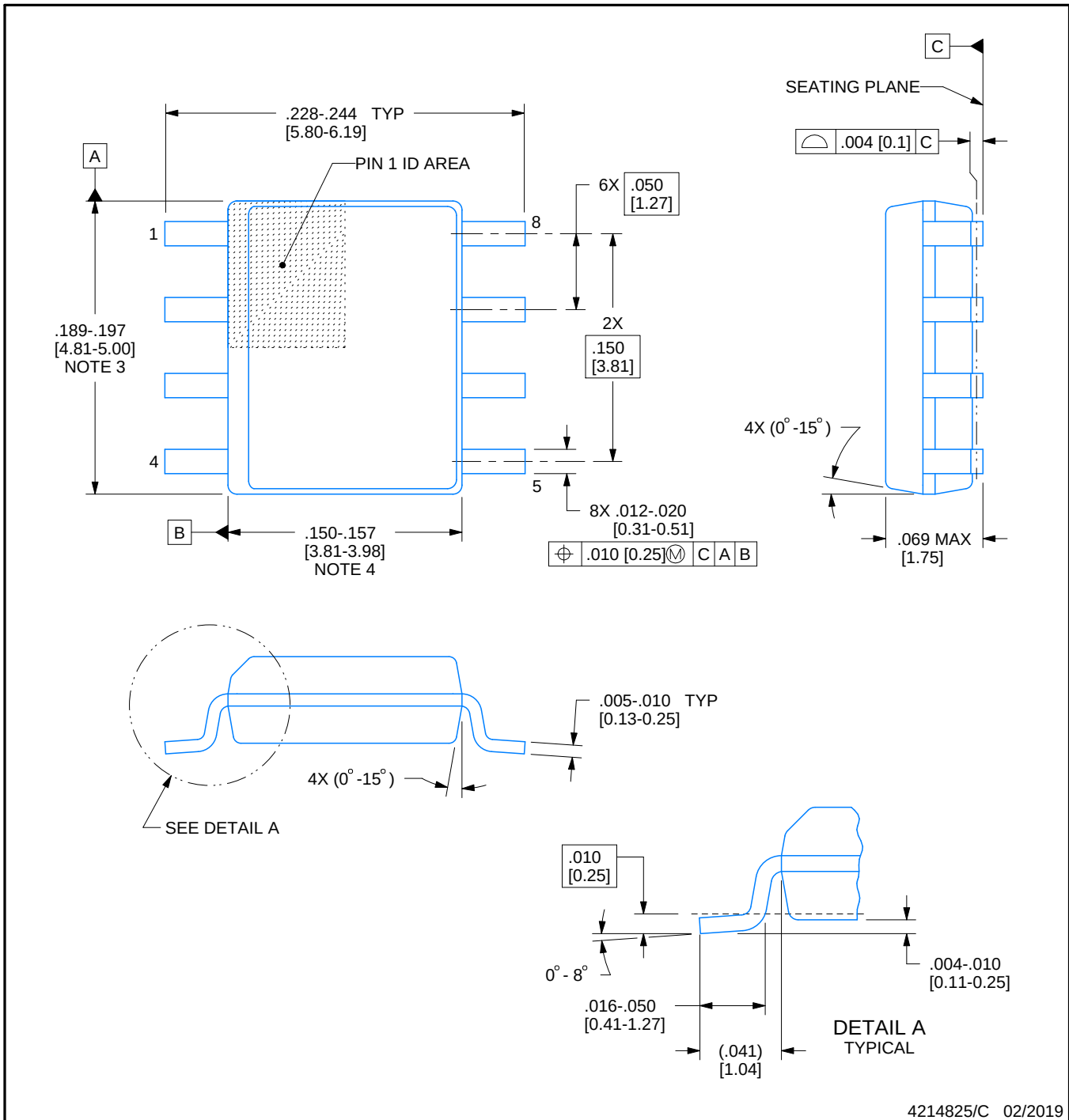


**D0008A**

# PACKAGE OUTLINE

**SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

## NOTES:

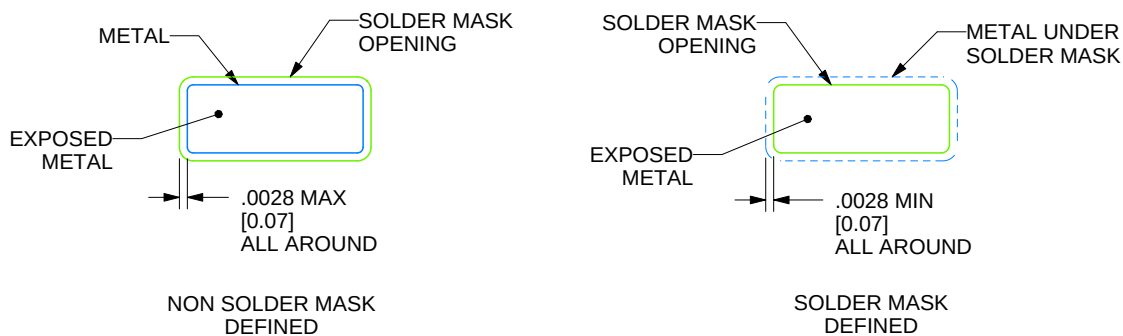
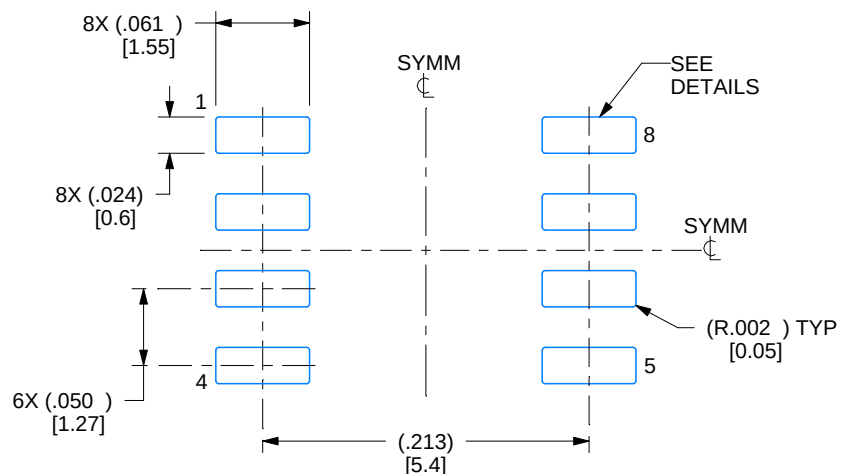
1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate 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



4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

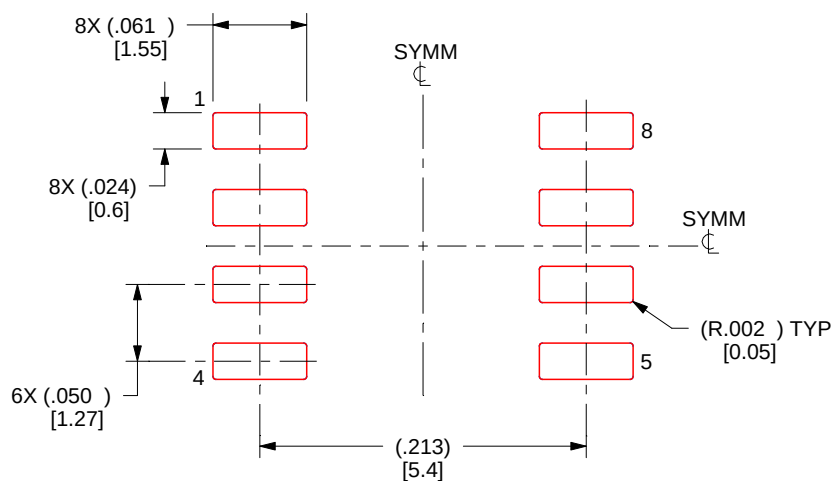
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## 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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