

## LMH6704 650 MHz Selectable Gain Buffer with Disable

Check for Samples: [LMH6704](#)

### FEATURES

- **Wideband operation**
  - $A_V = +1$ ,  $V_O = 0.5 V_{PP}$  650 MHz
  - $A_V = +2$ ,  $V_O = 0.5 V_{PP}$  450 MHz
  - $A_V = +2$ ,  $V_O = 2 V_{PP}$  400 MHz
- **High output current  $\pm 90$  mA**
- **Very low distortion**
  - 2<sup>nd</sup>/3<sup>rd</sup> harmonics (10 MHz,  $R_L = 100\Omega$ ): –62/–78dBc
  - Differential gain/Differential phase: 0.02%/0.02°
- **Low noise  $2.3nV/\sqrt{Hz}$**
- **High slew rate  $3000 V/\mu s$**
- **Supply current 11.5 mA**

### APPLICATIONS

- **HDTV, NTSC and PAL video systems**
- **Video switching and distribution**
- **ADC driver**
- **DAC buffer**
- **RGB driver**
- **High speed multiplexer**

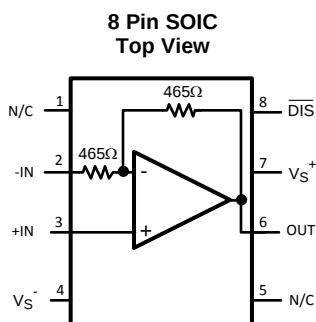
### DESCRIPTION

The LMH<sup>TM</sup>6704 is a very wideband, DC coupled selectable gain buffer designed specifically for wide dynamic range systems requiring exceptional signal fidelity. The LMH6704 includes on chip feedback and gain set resistors, simplifying PCB layout while providing user selectable gains of +1, +2 and –1 V/V. The LMH6704 provides a disable pin, which places the amplifier in a high output impedance, low power mode. The Disable pin may be allowed to float high.

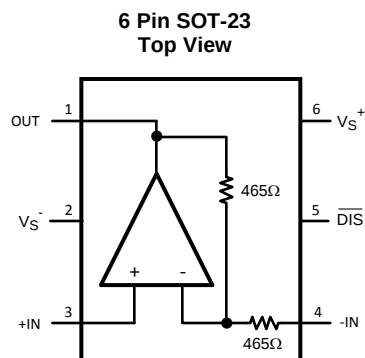
With a 650 MHz Small Signal Bandwidth ( $A_V = +1$ ), full power gain flatness to 200 MHz, and excellent Differential Gain and Phase, the LMH6704 is optimized for video applications. High resolution video systems will benefit from the LMH6704 ability to drive multiple video loads at low levels of differential gain or differential phase distortion.

The LMH6704 is constructed with proprietary high speed complementary bipolar process using proven current feedback circuit architectures. It is available in 8 Pin SOIC and 6 Pin SOT-23 packages.

### CONNECTION DIAGRAM



See Package Number D0008A



See Package Number DBV0006A



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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>

|                              |                                  |                    |
|------------------------------|----------------------------------|--------------------|
| ESD Tolerance <sup>(2)</sup> | Human Body Model                 | 2000V              |
|                              | Machine Model                    | 200V               |
| Supply Voltage               |                                  | 13.5V              |
| $I_{OUT}$                    |                                  | <sup>(3)</sup>     |
| Common-Mode Input Voltage    |                                  | $V_S^-$ to $V_S^+$ |
| Maximum Junction Temperature |                                  | 150°C              |
| Storage Temperature Range    |                                  | -65°C to 150°C     |
| Soldering Information        | Infrared or Convection (20 sec.) | 235°C              |
|                              | Wave Soldering (10 sec.)         | 260°C              |
|                              | Lead Temp. (soldering 10 sec.)   | 300°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 specifications, see the Electrical Characteristics tables.
- (2) 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).
- (3) The maximum output current ( $I_{OUT}$ ) is determined by device power dissipation limitations.

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

|                                  |                                   |                                   |
|----------------------------------|-----------------------------------|-----------------------------------|
| Nominal Supply Voltage           |                                   | ±4V to ±6V                        |
| Temperature Range <sup>(2)</sup> |                                   | -40°C to 85°C                     |
| Thermal Resistance               |                                   |                                   |
| <b>Package</b>                   | <b>(<math>\theta_{JC}</math>)</b> | <b>(<math>\theta_{JA}</math>)</b> |
| 8-Pin SOIC                       | 75°C/W                            | 160°C/W                           |
| 6-Pin SOT23                      | 120°C/W                           | 187°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 specifications, see the Electrical Characteristics tables.
- (2) The maximum power dissipation is a function of  $T_{J(MAX)}$ ,  $\theta_{JA}$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{J(MAX)} - T_A) / \theta_{JA}$ . All numbers apply for packages soldered directly onto a PC Board.

## Electrical Characteristics <sup>(1)</sup>

$T_A = +25^\circ\text{C}$ ,  $A_V = +2$ ,  $V_S = \pm 5\text{V}$ ,  $R_L = 100\Omega$ ; unless specified.

| Symbol                               | Parameter                           | Conditions                                           | Min <sup>(2)</sup>                        | Typ <sup>(2)</sup> | Max <sup>(2)</sup>                     | Units                        |
|--------------------------------------|-------------------------------------|------------------------------------------------------|-------------------------------------------|--------------------|----------------------------------------|------------------------------|
| <b>Dynamic Performance</b>           |                                     |                                                      |                                           |                    |                                        |                              |
| SSBW                                 | -3 dB Bandwidth                     | $V_{OUT} = 0.5 V_{PP}$ , $A_V = +1$                  |                                           | 650                |                                        | MHz                          |
| SSBW                                 |                                     | $V_{OUT} = 0.5 V_{PP}$                               |                                           | 450                |                                        |                              |
| LSBW                                 |                                     | $V_{OUT} = 2 V_{PP}$                                 |                                           | 400                |                                        |                              |
| $GF_{0.1dB}$                         | 0.1 dB Gain Bandwidth               | $V_{OUT} = 2 V_{PP}$                                 |                                           | 200                |                                        | MHz                          |
| SR                                   | Slew Rate                           | $V_{OUT} = 4 V_{PP}$ , 40% to 60% <sup>(3)</sup>     |                                           | 3000               |                                        | V/ $\mu\text{s}$             |
| TRS/TRL                              | Rise and Fall Time (10% to 90%)     | 2V Step                                              |                                           | 0.9                |                                        | ns                           |
| $t_s$                                | Settling Time to 0.1%               | 2V Step                                              |                                           | 10                 |                                        | ns                           |
| <b>Distortion and Noise Response</b> |                                     |                                                      |                                           |                    |                                        |                              |
| HD2L                                 | 2 <sup>nd</sup> Harmonic Distortion | $V_{OUT} = 2.0 V_{PP}$ , $f = 10\text{ MHz}$         |                                           | -62                |                                        | dBc                          |
| HD2H                                 |                                     | $V_{OUT} = 2.0 V_{PP}$ , $f = 40\text{ MHz}$         |                                           | -52                |                                        |                              |
| HD3L                                 | 3 <sup>rd</sup> Harmonic Distortion | $V_{OUT} = 2.0 V_{PP}$ , $f = 10\text{ MHz}$         |                                           | -78                |                                        | dBc                          |
| HD3H                                 |                                     | $V_{OUT} = 2.0 V_{PP}$ , $f = 40\text{ MHz}$         |                                           | -65                |                                        |                              |
| IMD                                  | Two-Tone Intermodulation            | $f = 10\text{ MHz}$ , $P_{OUT} = 10\text{ dBm/tone}$ |                                           | -65                |                                        | dBc                          |
| $V_N$                                | Output Noise Voltage                | $f = 100\text{ kHz}$ , $A_V = +2$                    |                                           | 10.5               |                                        | nV/ $\sqrt{\text{Hz}}$       |
|                                      |                                     | $A_V = +1$                                           |                                           | 9.3                |                                        |                              |
|                                      |                                     | $A_V = -1$                                           |                                           | 10.5               |                                        |                              |
| $I_{NN}$                             | Non-Inverting Input Noise Current   |                                                      |                                           | 3                  |                                        | pA/ $\sqrt{\text{Hz}}$       |
| DG                                   | Differential Gain                   | $R_L = 150\Omega$ , $f = 4.43\text{ MHz}$            |                                           | .02                |                                        | %                            |
| DP                                   | Differential Phase                  | $R_L = 150\Omega$ , $f = 4.43\text{ MHz}$            |                                           | 0.02               |                                        | deg                          |
| <b>Static, DC Performance</b>        |                                     |                                                      |                                           |                    |                                        |                              |
| $A_V$                                | Gain                                |                                                      | 1.98<br><b>1.96</b>                       | 2.00               | 2.02<br><b>2.04</b>                    | V/V                          |
|                                      | Gain Error                          |                                                      | -1<br><b>-2</b>                           |                    | +1<br><b>+2</b>                        | %                            |
| $V_{IO}$                             | Input Offset Voltage                |                                                      |                                           | 2                  | $\pm 7$<br><b><math>\pm 8.3</math></b> | mV                           |
| $DV_{IO}$                            | Input Offset Voltage Average Drift  |                                                      |                                           | 35                 |                                        | $\mu\text{V}/^\circ\text{C}$ |
| $I_{BN}$                             | Input Bias Current                  | Non-Inverting <sup>(4)</sup>                         |                                           | -5                 | $\pm 15$<br><b><math>\pm 18</math></b> | $\mu\text{A}$                |
| $I_{BI}$                             | Input Bias Current                  | Inverting                                            |                                           | 5                  | $\pm 22$<br><b><math>\pm 31</math></b> |                              |
| CMIR                                 | Common Mode Input Range             | $V_{IO} \leq 15\text{ mV}$                           | $\pm 1.9$                                 | $\pm 2$            |                                        | V                            |
| PSRR                                 | Power Supply Rejection Ratio        | DC                                                   | 48<br><b>47</b>                           | 52                 |                                        | dB                           |
| $V_O$                                | Output Voltage Swing                | $R_L = \infty$                                       | $\pm 3.3$<br><b><math>\pm 3.18</math></b> | $\pm 3.5$          |                                        | V                            |
|                                      |                                     | $R_L = 100\Omega$                                    | $\pm 3.2$<br><b><math>\pm 3.12</math></b> | $\pm 3.5$          |                                        |                              |
| $I_O$                                | Linear Output Current               | $V_{OUT} \leq 80\text{ mV}$                          | $\pm 55$                                  | $\pm 90$           |                                        | mA                           |
| $I_S$                                | Supply Current (Enabled)            | $\overline{DIS} = 2\text{V}$ , $R_L = \infty$        |                                           | 11.5               | 12.5<br><b>13.7</b>                    | mA                           |
|                                      | Supply Current (Disabled)           | $\overline{DIS} = 0.8\text{V}$ , $R_L = \infty$      |                                           | 0.25               | 0.9<br><b>0.925</b>                    |                              |

(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  $T_J = T_A$ . Parametric performance is indicated in the electrical tables under conditions of internal self-heating where  $T_J > T_A$ . Min/Max ratings are based on production testing unless otherwise specified.

(2) 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 on shipped production material.

(3) Slew Rate is the average of the rising and falling edges.

(4) Negative current implies current flowing out of the device.

**Electrical Characteristics <sup>(1)</sup> (continued)**

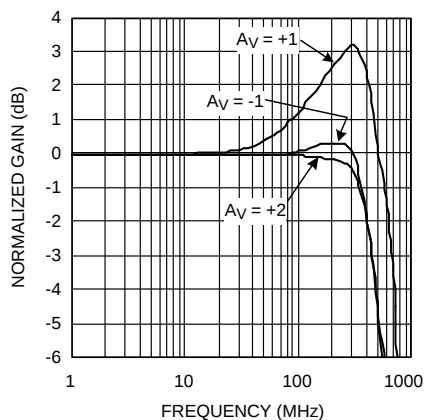
$T_A = +25^\circ\text{C}$ ,  $A_V = +2$ ,  $V_S = \pm 5\text{V}$ ,  $R_L = 100\Omega$ ; unless specified.

| Symbol                                           | Parameter                        | Conditions                                  | Min <sup>(2)</sup> | Typ <sup>(2)</sup> | Max <sup>(2)</sup>     | Units            |
|--------------------------------------------------|----------------------------------|---------------------------------------------|--------------------|--------------------|------------------------|------------------|
| $R_F$ & $R_G$                                    | Internal $R_F$ and $R_G$         |                                             | 375                | 465                | 563                    | $\Omega$         |
| $R_{OUT}$                                        | Closed Loop Output Resistance    | DC                                          |                    | 0.05               |                        | $\Omega$         |
| $R_{IN+}$                                        | Input Resistance                 |                                             |                    | 1                  |                        | $M\Omega$        |
| $C_{IN+}$                                        | Input Capacitance                |                                             |                    | 1                  |                        | pF               |
| <b>Enable/Disable Performance (Disabled Low)</b> |                                  |                                             |                    |                    |                        |                  |
| $T_{ON}$                                         | Enable Time                      |                                             |                    | 10                 |                        | ns               |
| $T_{OFF}$                                        | Disable Time                     |                                             |                    | 10                 |                        | ns               |
|                                                  | Output Glitch                    |                                             |                    | 50                 |                        | mV <sub>PP</sub> |
| $V_{IH}$                                         | Enable Voltage                   | $\overline{DIS} \geq V_{IH}$                | 2.0                |                    |                        | V                |
| $V_{IL}$                                         | Disable Voltage                  | $\overline{DIS} \leq V_{IL}$                |                    |                    | 0.8                    |                  |
| $I_{IH}$                                         | Disable Input Bias Current, High | $\overline{DIS} = V^+$ , <sup>(4)</sup>     |                    | -1                 | <b>±50</b>             | $\mu\text{A}$    |
| $I_{IL}$                                         | Disable Input Bias Current, Low  | $\overline{DIS} = 0\text{V}$ <sup>(4)</sup> | <b>0</b>           | -100               | <b>-350</b>            | $\mu\text{A}$    |
| $I_{OZ}$                                         | Disabled Output Leakage Current  | $A_V = +1$ , $V_{OUT} = \pm 1.8\text{V}$    |                    | 0.2                | $\pm 25$<br><b>±50</b> | $\mu\text{A}$    |

## Typical Performance Characteristics

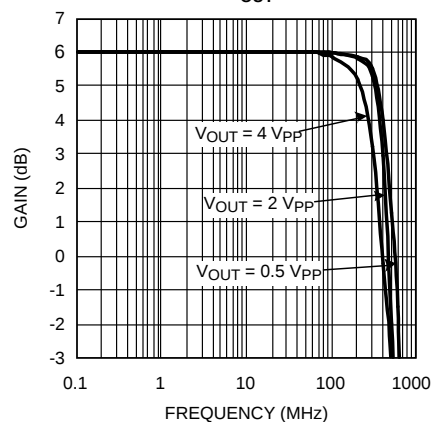
( $T_A = 25^\circ\text{C}$ ,  $V_S = \pm 5\text{V}$ ,  $R_L = 100\Omega$ ,  $A_V = +2$ ,  $V_{OUT} = 0.5 V_{PP}$ ; Unless Specified).

**Small Signal Frequency Response  
vs.  
Gain**



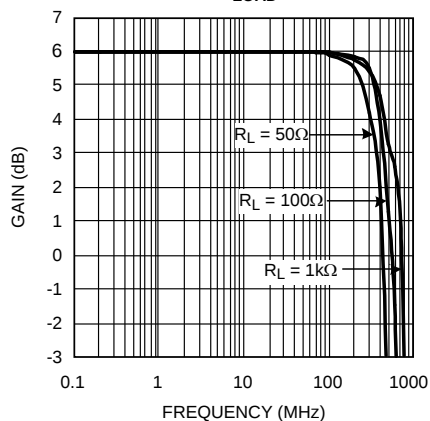
**Figure 1.**

**Frequency Response  
vs.  
 $V_{OUT}$**



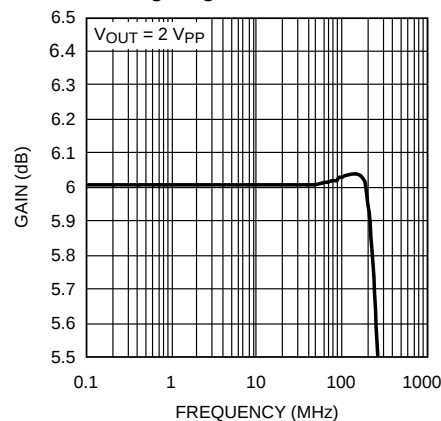
**Figure 2.**

**Small Signal Frequency Response  
vs.  
 $R_{LOAD}$**



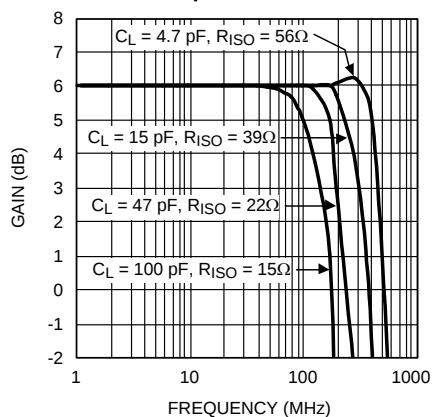
**Figure 3.**

**Large Signal Gain Flatness**



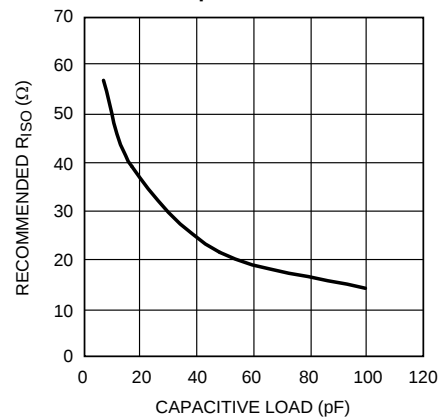
**Figure 4.**

**Small Signal Frequency Response  
vs.  
Capacitive Load**



**Figure 5.**

**Series Output Isolation Resistance  
vs.  
Capacitive Load**

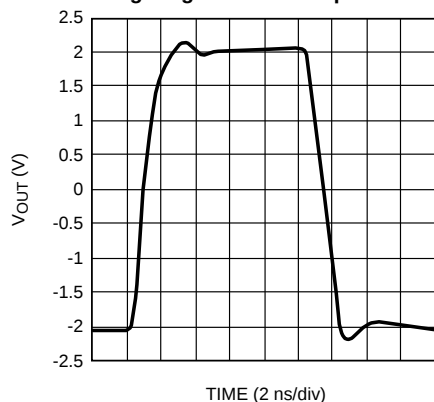


**Figure 6.**

## Typical Performance Characteristics (continued)

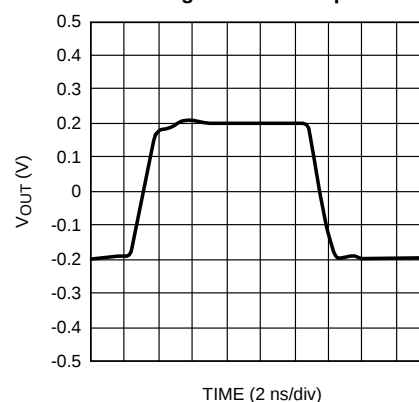
( $T_A = 25^\circ\text{C}$ ,  $V_S = \pm 5\text{V}$ ,  $R_L = 100\Omega$ ,  $A_V = +2$ ,  $V_{OUT} = 0.5\text{ V}_{PP}$ ; Unless Specified).

**Large Signal Pulse Response**



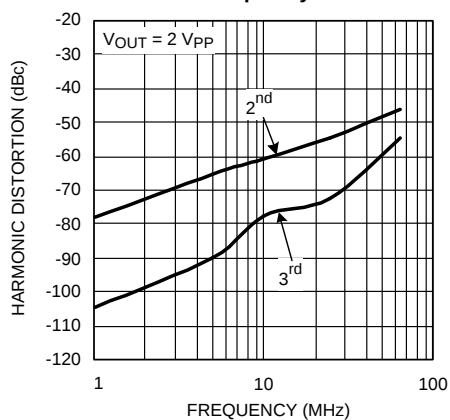
**Figure 7.**

**Small Signal Pulse Response**



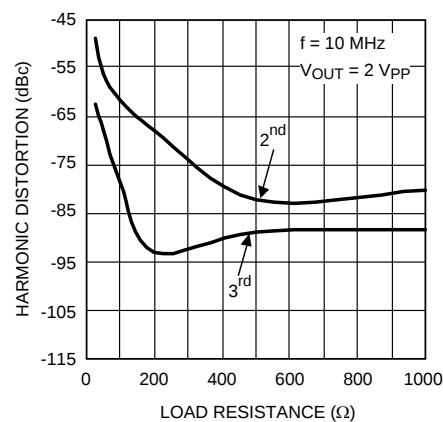
**Figure 8.**

**Harmonic Distortion  
vs.  
Frequency**



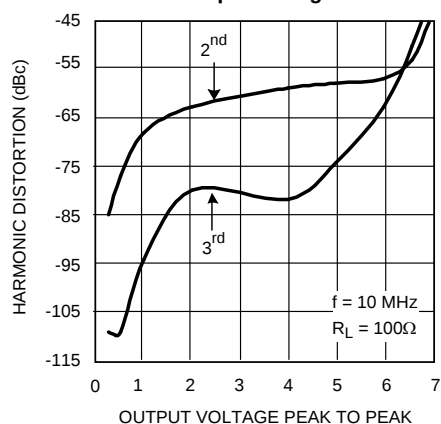
**Figure 9.**

**Harmonic Distortion  
vs.  
Load**



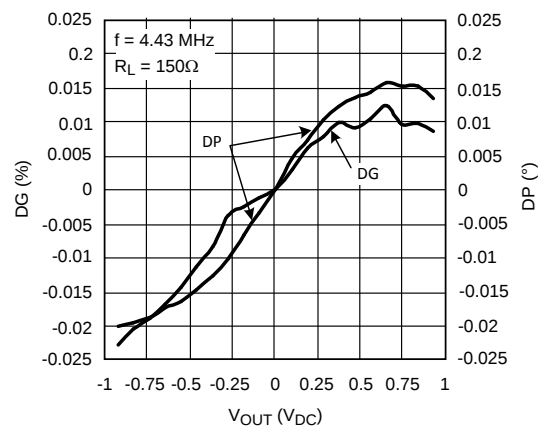
**Figure 10.**

**Harmonic Distortion  
vs.  
Output Voltage**



**Figure 11.**

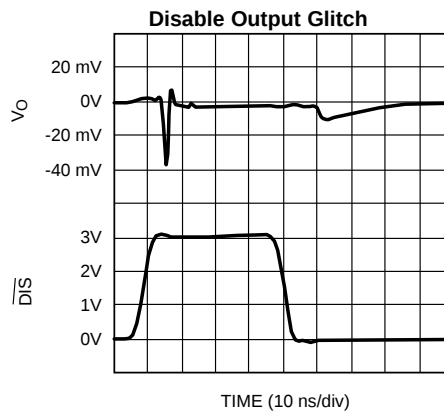
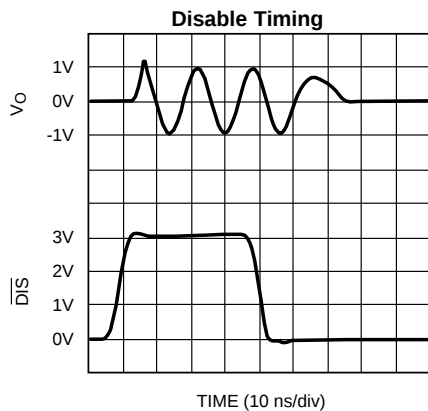
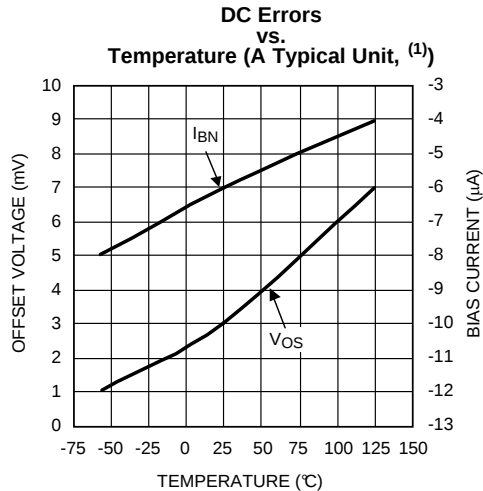
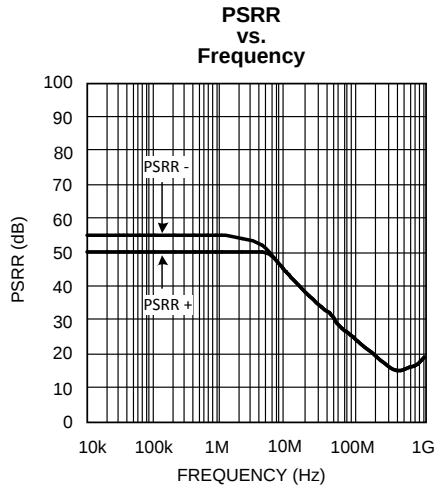
**DG/DP**



**Figure 12.**

## Typical Performance Characteristics (continued)

( $T_A = 25^\circ\text{C}$ ,  $V_S = \pm 5\text{V}$ ,  $R_L = 100\Omega$ ,  $A_V = +2$ ,  $V_{OUT} = 0.5 V_{PP}$ ; Unless Specified).



(1) Negative current implies current flowing out of the device.

## APPLICATION INFORMATION

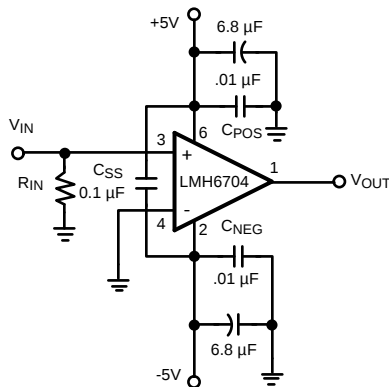


Figure 17. Recommended Gain of +2 Circuit

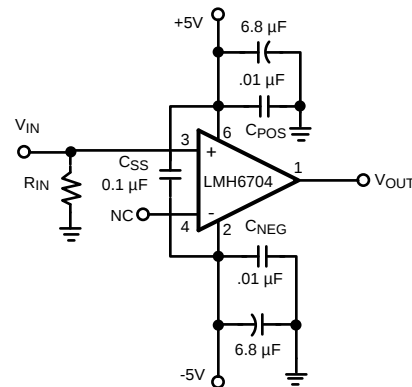


Figure 18. Recommended Gain of +1 Circuit

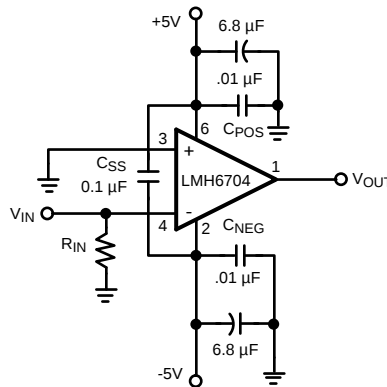


Figure 19. Recommended Gain of -1 Circuit

## GENERAL INFORMATION

The LMH6704 is a high speed current feedback Selectable Gain Buffer (SGB), optimized for very high speed and low distortion. With its internal feedback and gain-setting resistors the LMH6704 offers excellent AC performance while simplifying board layout and minimizing the affects of layout related parasitic components. The LMH6704 has no internal ground reference so single or split supply configurations are both equally useful.

## SETTING THE CLOSED LOOP GAIN

The LMH6704 is a current feedback amplifier with on-chip  $R_F = R_G = 465\Omega$ . As such it can be configured with an  $A_V = +2$ ,  $A_V = +1$ , or an  $A_V = -1$  by connecting pins 3 and 4 as described in [Table 1](#).

Table 1.

| GAIN $A_V$ | Input Connections             |                           |
|------------|-------------------------------|---------------------------|
|            | Non-Inverting (Pin 3, SOT-23) | Inverting (Pin 4, SOT-23) |
| -1 V/V     | Ground                        | Input Signal              |
| +1 V/V     | Input Signal                  | NC (Open)                 |
| +2 V/V     | Input Signal                  | Ground                    |

The gain accuracy of the LMH6704 is accurate over temperature to within  $\pm 1\%$ . The internal gain setting resistors,  $R_F$  and  $R_G$ , match very well. The LMH6704 architecture takes advantage of the fact that the internal gain setting resistors track each other well over a wide range of temperature and process variation to keep the overall gain constant, despite the fact that the individual resistors have nominal temperature drifts. Therefore, using external resistors in series with  $R_G$  to change the gain will result in poor gain accuracy over temperature.

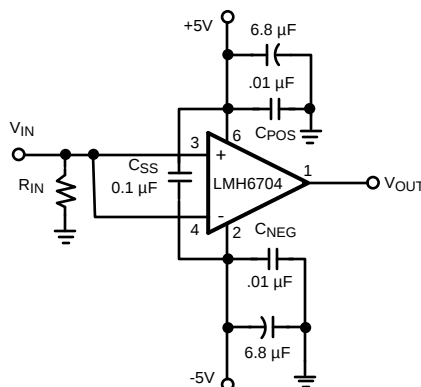


Figure 20. Alternate Unity Gain Configuration

## UNITY GAIN COMPENSATION

With a current feedback Selectable Gain Buffer like the LMH6704, the feedback resistor is a compromise between the value needed for stability at unity gain and the optimized value needed at a gain of two. In standard open-loop current feedback operational amplifiers the feedback resistor,  $R_F$ , is external and its value can be adjusted to match the required gain. Since the feedback resistor is integrated in the LMH6704, it is not possible to adjust its value. However, we can employ the circuit shown in Figure 20. This circuit modifies the noise gain of the amplifier to eliminate the peaking associated with using the circuit shown in Figure 18. The frequency response is shown in Figure 21. The decreased peaking does come at a price as the output referred voltage noise density increases by a factor of 1.1.

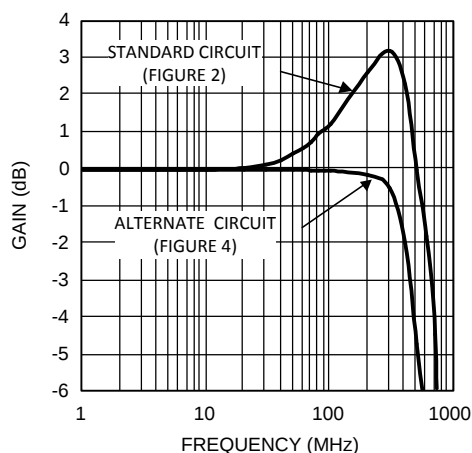


Figure 21. Unity Gain Frequency Response

## OUTPUT VOLTAGE NOISE

Open-loop operational amplifiers specify three input referred noise parameters: input voltage noise, non-inverting input current noise, and inverting input current noise. These specifications are used to calculate the total voltage noise produced at the output of the amplifier. The LMH6704 is a closed loop amplifier with internal resistors, thus only the non-inverting input current noise flows through external components. All other noise sources are internal to the part. There are four possible values for the noise at the output depending on the gain configuration as shown in Table 2. For more information on calculating noise in current feedback amplifiers see Application Notes OA-12 and AN104 available at [www.ti.com](http://www.ti.com).

The total noise voltage at the output can be calculated using Equation 1:

$$E_O = \sqrt{(4kTR_{SOURCE} + (I_{BN} * R_{SOURCE})^2) * G_N^2 + (OUTPUT REFERRED NOISE VOLTAGE)^2}, \text{ Where}$$

$G_N$  = Noise Gain and  $4kT = 16E-21$  Joules @ Room Temperature

(1)

For example, if an  $A_V = +2$  configuration is used with a source impedance of  $37.5\Omega$  (parallel combination of  $75\Omega$  source and  $75\Omega$  termination impedances), where " $I_{BN}$ " is  $18.5\text{pA}/\sqrt{\text{Hz}}$  and the output referred voltage noise (excluding non-inverting input noise current) can be found in Table 2. The total noise ( $E_O$ ) at the output can be calculated as:

$$E_O = \sqrt{(16E-21 * 37.5 + (18.5 \text{ pA} * 37.5)^2) * 2^2 + (10.5 \text{ nV})^2} = 10.6 \text{ nV} / \sqrt{\text{Hz}}$$

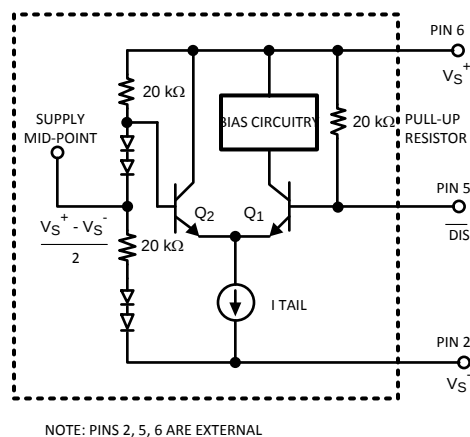
(2)

**Table 2. Measured Output Noise Voltage<sup>(1)</sup>**

| Gain ( $A_V$ )                          | Output Referred Voltage Noise<br>( $\text{nV}/\sqrt{\text{Hz}}$ ), excluding non-inverting noise current |
|-----------------------------------------|----------------------------------------------------------------------------------------------------------|
| +2                                      | 10.5                                                                                                     |
| +1                                      | 9.3                                                                                                      |
| +1, alternate method shown in Figure 20 | 10.5                                                                                                     |
| -1                                      | 10.5                                                                                                     |

(1) Note:  $f \geq 100 \text{ kHz}$

## ENABLE/DISABLE



**Figure 22. DIS Pin Simplified Schematic**

The LMH6704 has a TTL logic compatible disable function. Apply a logic low ( $<0.8\text{V}$ ) to the DS pin and the LMH6704 is disabled. Apply a logic high ( $>2.0\text{V}$ ), or let the pin float and the LMH6704 is enabled. Voltage, not current, at the Disable pin (DS) determines the enable/disable state. Care must be exercised to prevent the disable pin voltage from going more than  $.8\text{V}$  below the midpoint of the supply voltages ( $0\text{V}$  with split supplies,  $V^+/2$  with single supply biasing). Doing so could cause transistor Q1 to Zener resulting in damage to the disable circuit (See Figure 22 or the simplified internal schematic diagram using SOT-23 package pin numbers). The core amplifier is unaffected by this, but the disable operation could become permanently slower as a result.

Disabled, the LMH6704 inputs and output become high impedances. While disabled the LMH6704 quiescent current is approximately  $250 \mu\text{A}$ . Because of the pull up resistor on the disable circuit, the  $I_{CC}$  and  $I_{EE}$  currents (positive and negative supply currents respectively) are not balanced in the disabled state. The positive supply current ( $I_{CC}$ ) is approximately  $350 \mu\text{A}$  while the negative supply current ( $I_{EE}$ ) is only  $250 \mu\text{A}$ . The remaining  $I_{EE}$  current of  $100 \mu\text{A}$  flows through the disable pin.

The disable function can be used to create analog switches or multiplexers. Implement a single analog switch with one LMH6704 positioned between an input and output. Create an analog multiplexer with several LMH6704's. Use the circuit shown in for multiplexer applications because there is no  $R_G$  to shunt signals to ground.

## EVALUATION BOARDS

Texas Instruments provides 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 | Evaluation Board Part Number |
|-----------|---------|------------------------------|
| LMH6704MA | SOIC-8  | CLC730227                    |
| LMH6704MF | SOT23-6 | CLC730216                    |

## DRIVING CAPACITIVE LOADS

Capacitive output loading applications will benefit from the use of a series output resistor  $R_{ISO}$ . Figure 23 shows the use of a series output resistor,  $R_{ISO}$ , to stabilize the amplifier output under capacitive loading. Capacitive loads of 5 to 120 pF are the most critical, causing ringing, frequency response peaking and possible oscillation. The chart “Suggested  $R_{ISO}$  vs. Cap Load” gives a recommended value for selecting a series output resistor for mitigating capacitive loads. The values suggested in the charts are selected for 0.5 dB 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  $R_{ISO}$  can be reduced slightly from the recommended values.

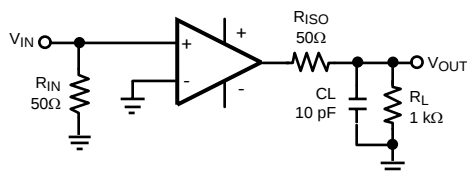


Figure 23. Decoupling Capacitive Loads

## LAYOUT CONSIDERATIONS

Whenever questions about layout arise, use the evaluation board as a guide. To reduce parasitic capacitances ground and power planes should be removed near the input and output pins. For long signal paths controlled impedance lines should be used, along with impedance matching elements at both ends. Bypass capacitors should be placed as close to the device as possible. Bypass capacitors from each rail to ground are applied in pairs. The larger electrolytic bypass capacitors can be located farther from the device, the smaller ceramic capacitors should be placed as close to the device as possible. In Figure 17, Figure 18, and Figure 19  $C_{SS}$  is optional, but is recommended for best second order harmonic distortion. Another option to using  $C_{SS}$  is to use pairs of 0.01  $\mu$ F and 0.1  $\mu$ F ceramic capacitors for each supply bypass.

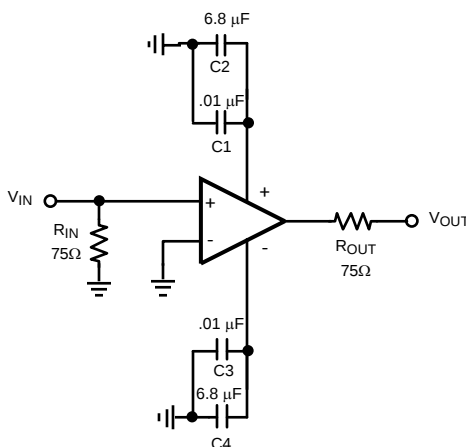


Figure 24. Typical Video Application

## VIDEO PERFORMANCE

The LMH6704 has been designed to provide excellent performance with production quality video signals in a wide variety of formats such as HDTV and High Resolution VGA. NTSC and PAL performance is nearly flawless with DG of 0.02% and DP of 0.02°. 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. [Figure 24](#) shows a typical configuration for driving a 75Ω Cable. The amplifier is configured for a gain of two to make up for the 6 dB of loss in  $R_{OUT}$ .

## POWER DISSIPATION

Follow these steps to determine the Maximum power dissipation for the LMH6704:

1. Calculate the quiescent (no-load) power:

$$P_{AMP} = I_{CC} \cdot (V_S) \quad (3)$$

where  $V_S = V^+ - V^-$

2. Calculate the RMS power dissipated in the output stage:

$$P_D (rms) = rms ((V_S - V_{OUT}) \times I_{OUT}) \quad (4)$$

where  $V_{OUT}$  and  $I_{OUT}$  are the voltage and current across the external load and  $V_S$  is the total supply current

3. Calculate the total RMS power:

$$P_T = P_{AMP} + P_D \quad (5)$$

The maximum power that the LMH6704, package can dissipate at a given temperature can be derived with the following equation:

$P_{MAX} = (150^\circ - T_{AMB}) / \theta_{JA}$ , where  $T_{AMB}$  = Ambient temperature ( $^\circ\text{C}$ ) and  $\theta_{JA}$  = Thermal resistance, from junction to ambient, for a given package ( $^\circ\text{C/W}$ ). For the SOT-23 package  $\theta_{JA}$  is  $187^\circ\text{C/W}$ .

## ESD PROTECTION

The LMH6704 is protected against electrostatic discharge (ESD) on all pins. The LMH6704 will survive 2000V Human Body model and 200V Machine model events. Input and Output pins have ESD diodes to either supply pin ( $V^+$  and  $V^-$ ) which are reverse biased and essentially have no effect under most normal operating conditions. There are occasions, however, when the ESD diodes will be evident. If the LMH6704 is driven by a large signal while the device is powered down, the ESD diodes might enter forward operating region and conduct. The current that flows through the ESD diodes will either exit the chip through the supply pins or will flow through the device, hence it is possible to inadvertently power up the LMH6704 with a large signal applied to the input pins. Shorting the power pins to each other will prevent the chip from being powered up through the input.

## REVISION HISTORY

| Changes from Revision B (March 2013) to Revision C         | Page               |
|------------------------------------------------------------|--------------------|
| • Changed layout of National Data Sheet to TI format ..... | <a href="#">12</a> |

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LMH6704MA/NOPB   | ACTIVE        | SOIC         | D                  | 8    | 95             | RoHS & Green    | SN                                   | Level-1-260C-UNLIM   | -40 to 85    | LMH67<br>04MA           | <a href="#">Samples</a> |
| LMH6704MF/NOPB   | ACTIVE        | SOT-23       | DBV                | 6    | 1000           | RoHS & Green    | SN                                   | Level-1-260C-UNLIM   | -40 to 85    | B07A                    | <a href="#">Samples</a> |
| LMH6704MFX/NOPB  | ACTIVE        | SOT-23       | DBV                | 6    | 3000           | RoHS & Green    | SN                                   | Level-1-260C-UNLIM   | -40 to 85    | B07A                    | <a href="#">Samples</a> |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBsolete:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

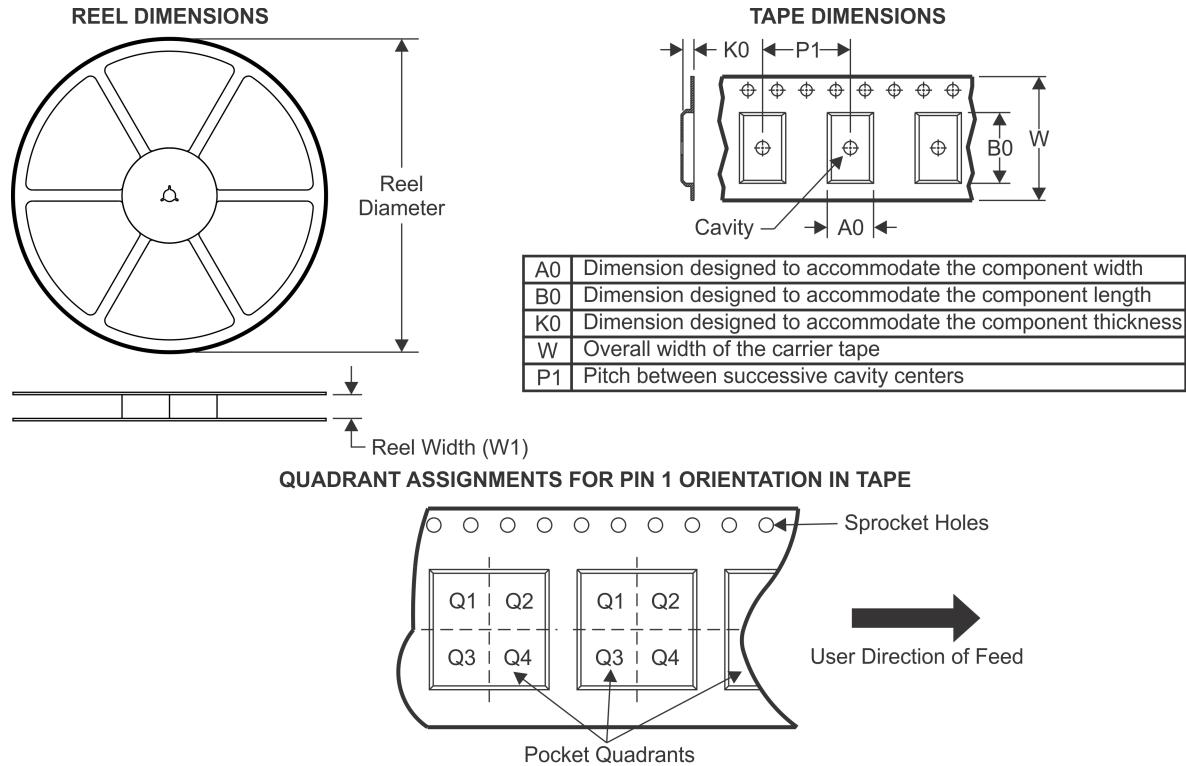
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

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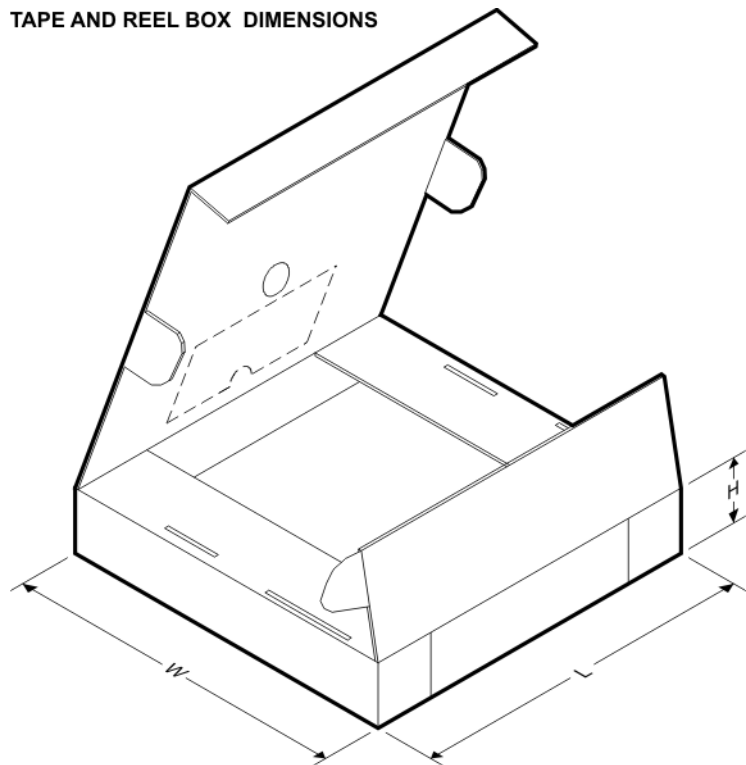
## TAPE AND REEL INFORMATION



\*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 |
|-----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LMH6704MF/NOPB  | SOT-23       | DBV             | 6    | 1000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LMH6704MFX/NOPB | SOT-23       | DBV             | 6    | 3000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |

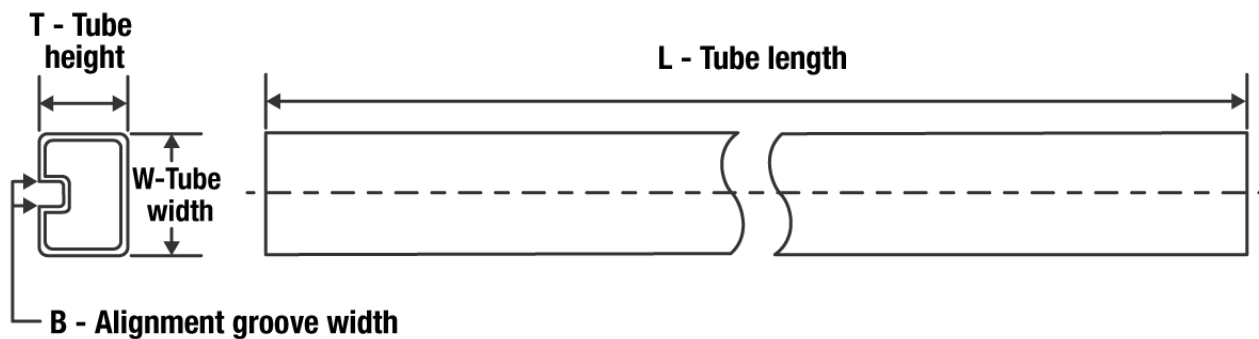
## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device          | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LMH6704MF/NOPB  | SOT-23       | DBV             | 6    | 1000 | 208.0       | 191.0      | 35.0        |
| LMH6704MFX/NOPB | SOT-23       | DBV             | 6    | 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) |
|----------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| LMH6704MA/NOPB | D            | SOIC         | 8    | 95  | 495    | 8      | 4064   | 3.05   |

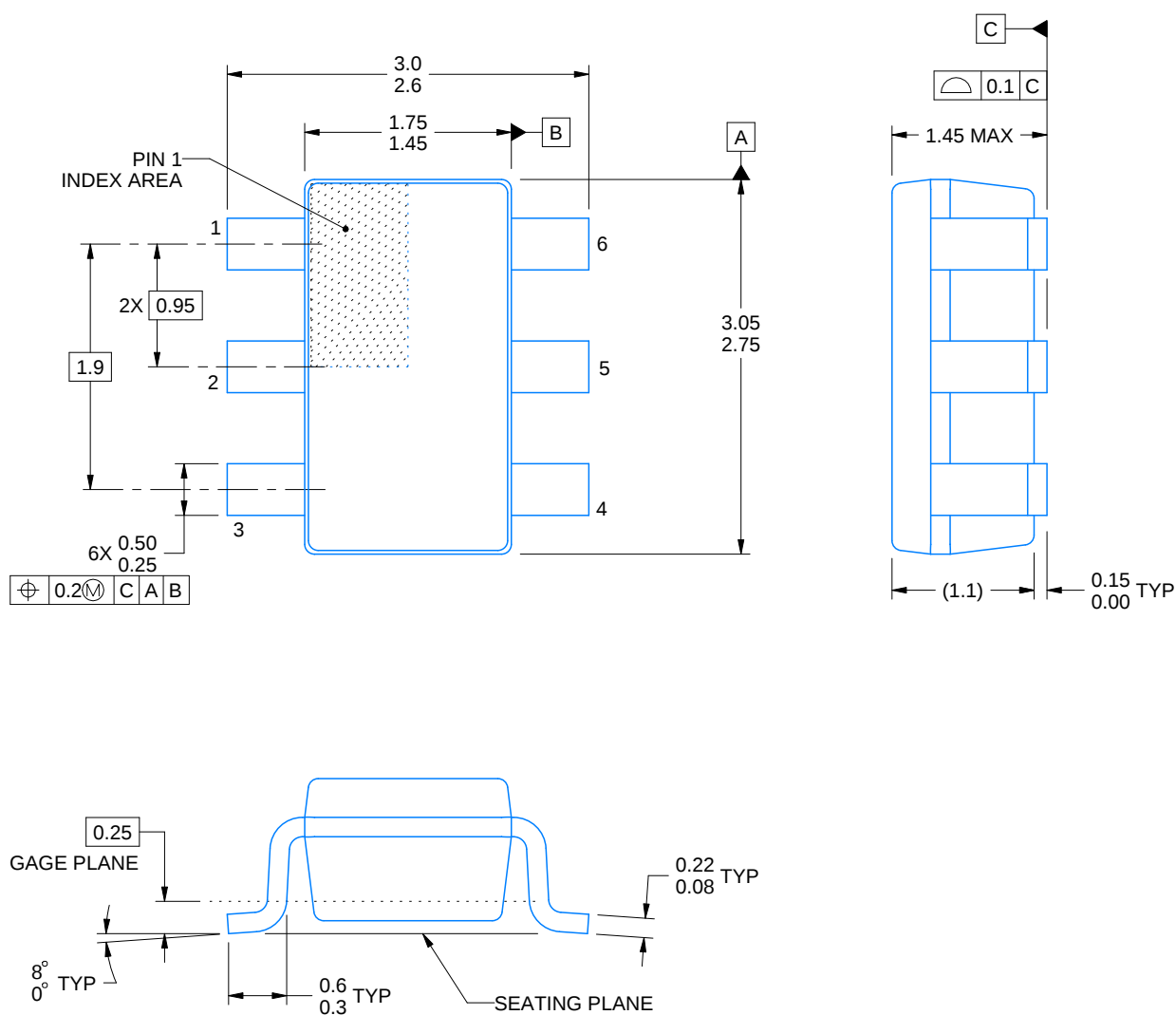


**DBV0006A**

# PACKAGE OUTLINE

**SOT-23 - 1.45 mm max height**

SMALL OUTLINE TRANSISTOR



4214840/C 06/2021

## NOTES:

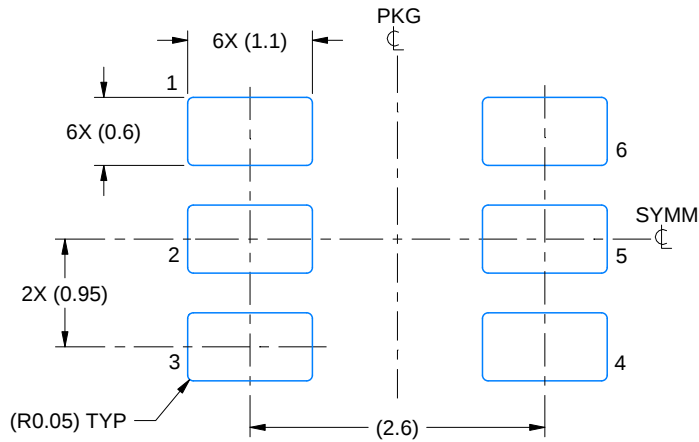
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.25 per side.
4. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
5. Reference JEDEC MO-178.

# EXAMPLE BOARD LAYOUT

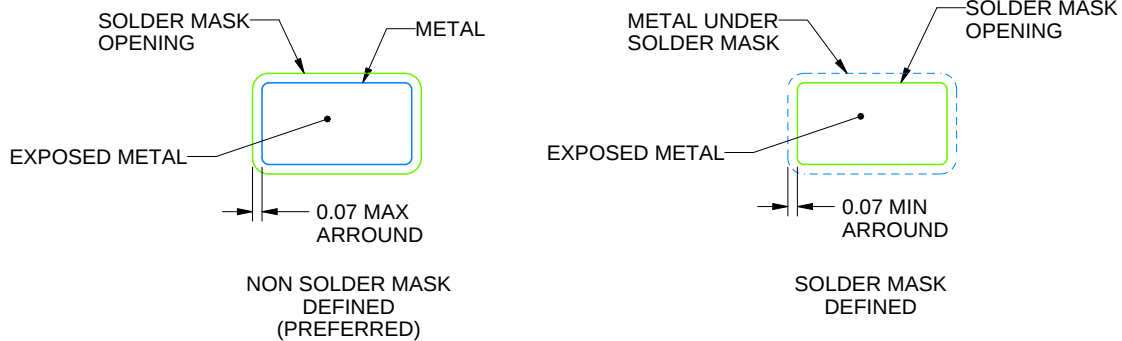
DBV0006A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:15X



SOLDER MASK DETAILS

4214840/C 06/2021

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

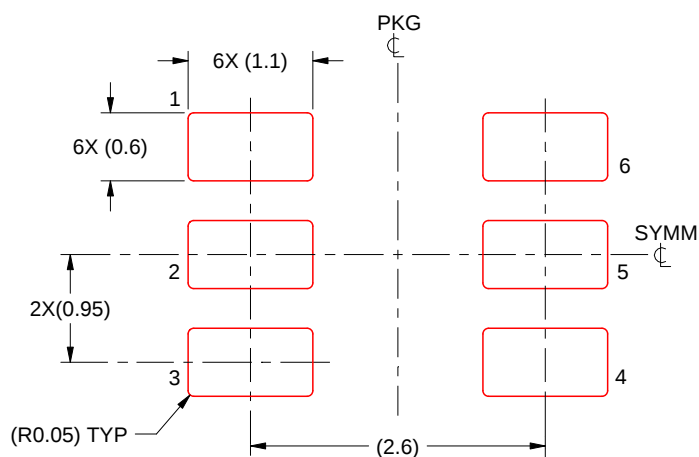
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

DBV0006A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR

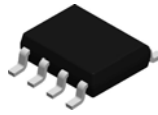


SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:15X

4214840/C 06/2021

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.

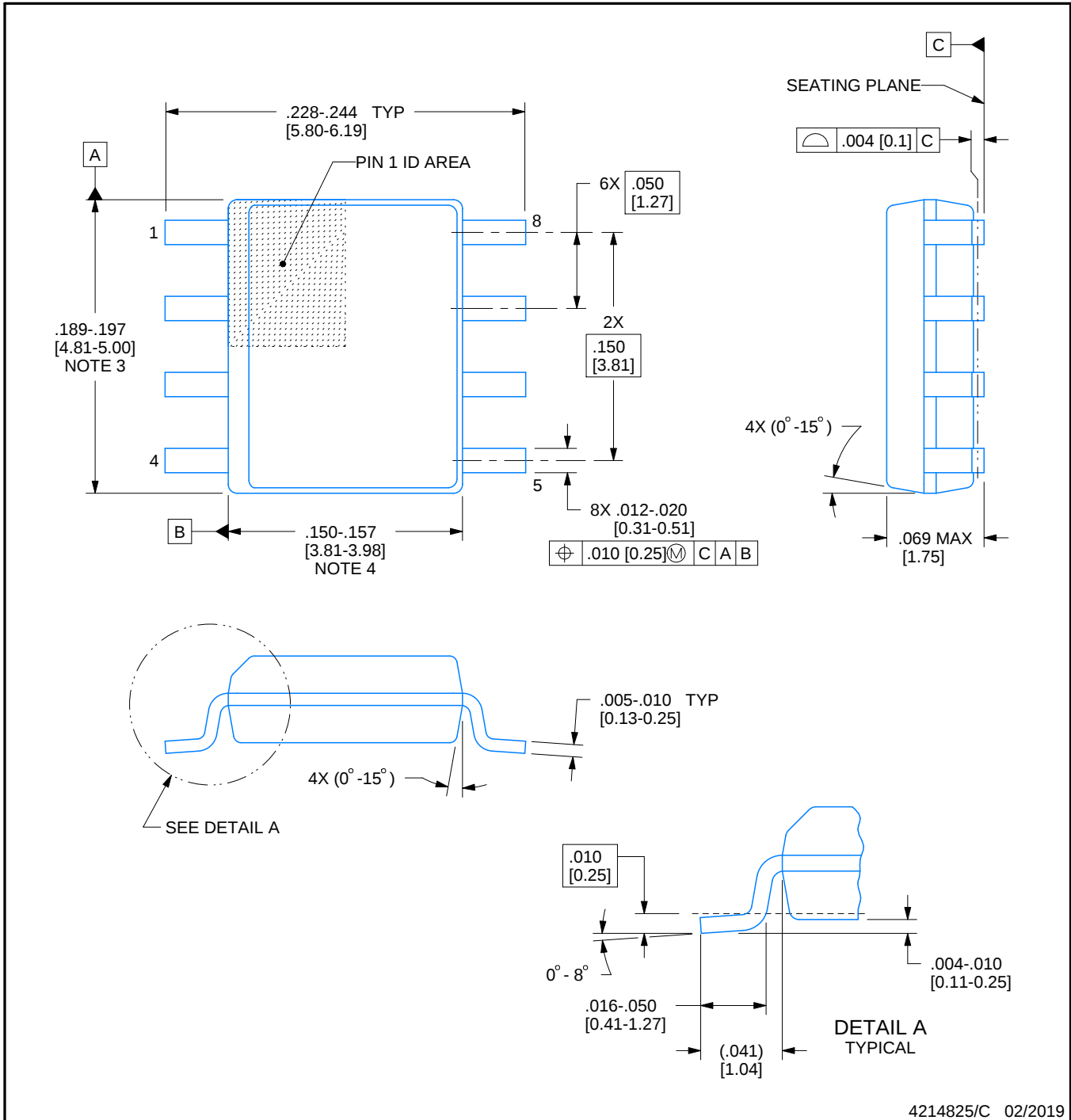


**D0008A**

# PACKAGE OUTLINE

**SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT



## 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.

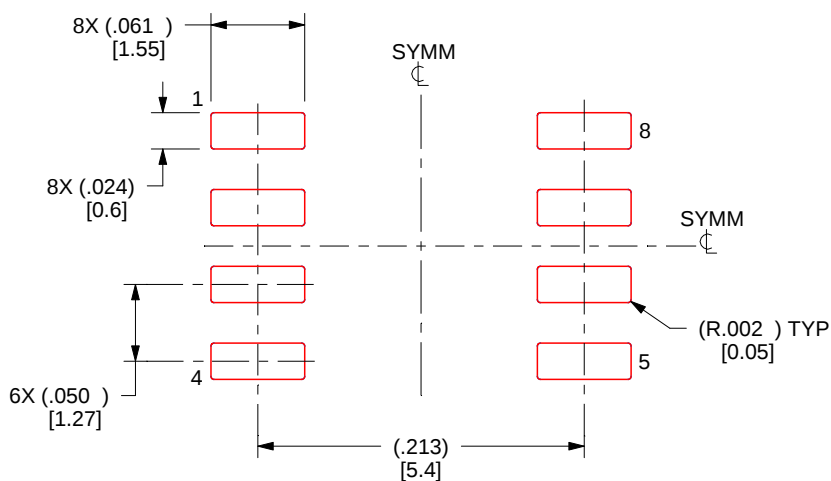


## EXAMPLE STENCIL DESIGN

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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