LME49880 Overture E-Series Dual JFET Input Audio Operational Amplifier



Literature Number: SNAS455B



## LME49880 Overture® E-Series

# **Dual JFET Input Audio Operational Amplifier**

### **General Description**

The LME49880 is part of the ultra-low distortion, low noise, high slew rate operational amplifier series optimized and fully specified for high performance, high fidelity application. The LME49880 is developed in JFET technology and reducing the flicker noise as well as the noise corner frequency significantly. It combines low voltage noise density (7nV/ $\sqrt{Hz}$ ) with very low THD+N (0.00003%). The LME49880 has a high slew rate of ±17 V/µs and an output current capability of ±22mA. It drives 600 $\Omega$  loads to within 1.3V of either power supply voltage.

The LME49880 has a wide supply range of  $\pm$ 5V to  $\pm$ 17V. Its outstanding GAIN (120dB), and low input bias current (5pA) give the amplifier excellent operational amplifier DC performance. The LME49880 is unity gain stable and capable of driving complex loads with values as high as 100pF. It is available in an 8-lead narrow body PSOP.

## Key Specifications

- Input Bias Current 5pA (typ) Power Supply Voltage Range ±5V to ±17V THD+N  $(A_V = 1, V_{OUT} = 3V_{BMS}, f_{IN} = 1kHz)$  $R_1 = 2k\Omega$ 0.00003% (typ)  $R_{1} = 600\Omega$ 0.00003% (typ) Slew Rate ±17V/µs (typ) Gain Bandwidth Product 25MHz (typ) Open Loop Gain (R<sub>1</sub> = 600Ω) 115dB (typ)  $7nV/\sqrt{Hz}$  (typ) Input Noise Density Input Offset Voltage 5mV (typ)
- CMRR 110dB (typ)

 $V_{CC} = \pm 15V, V_{O} = 3V_{RMS}, R_{L} = 600\Omega$ 

FREQUENCY (Hz)

FIGURE 2: THD+N vs Frequency

## **Features**

- Easily drives 600Ω loads
- Output short circuit protection

## **Applications**

- Ultra high quality audio signal processing
- Preamplifier
- Spectrum analyzers
- Ultrasound preamplifier

0.1

0.01

0.001

0.0001

0.00001

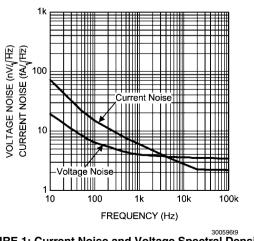
0.000001

(%) N + OHJ

Active filters



## **Typical Application**





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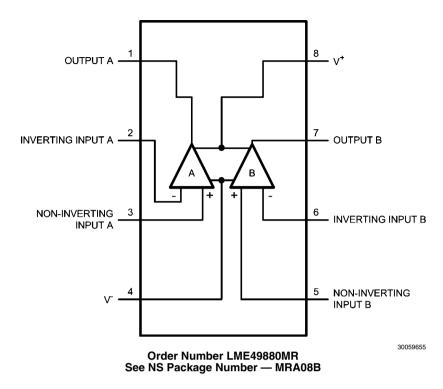
#### www.national.com

20k

300596s0

April 22, 2010

## **Connection Diagram**



## **Ordering Information**

#### **Ordering Information**

| Order Number | Package                       | Package DWG # | Transport Media    | MSL Level | Green Status     |
|--------------|-------------------------------|---------------|--------------------|-----------|------------------|
| LME49880MR   | 8 Ld PSOP<br>with Exposed Pad | MRA08B        | 95 units           | 3         | RoHS and noSb/Br |
| LME49880MRX  | 8 Ld PSOP<br>with Exposed Pad | MRA08B        | 2500 units on rail | 3         | RoHS and noSb/Br |

## Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

| Power Supply Voltage                                |                            |
|---|----------------------------|
| (V <sub>S</sub> = V <sup>+</sup> - V <sup>-</sup> ) | 36V                        |
| Storage Temperature                                 | –65°C to 150°C             |
| Input Voltage                                       | (V-) - 0.3V to (V+) + 0.3V |
| Output Short Circuit (Note 3)                       | Continuous                 |
| Power Dissipation                                   | Internally Limited         |
| ESD Rating (Note 4)                                 | 2000V                      |
| ESD Rating (Note 5)                                 | 200V                       |

| ESD Rating (Note 8)<br>Junction Temperature | 1000V<br>150°C |  |
|---|----------------|--|
| Thermal Resistance                          |                |  |
| θ <sub>JA</sub> (PSOP)                      | 55°C/W         |  |
| Solder Information                          |                |  |
| Infrared or Convection (20 sec)             | 260°C          |  |

## Operating Ratings (Note 1)

Temperature Range

| $T_{MIN} \le T_A \le T_{MAX}$ | $-40^{\circ}C \le T_A \le 85^{\circ}C$ |
|-------------------------------|--|
| Supply Voltage Range          | $\pm 5V \le V_S \le \pm 17V$           |

# **Electrical Characteristics** (*Note 2*) The following specifications apply for $V_S = \pm 15V$ , $T_A = 25$ °C, unless otherwise specified.

|                         |  |  | LME               | LME49880             |               |
|-------------------------|--|--|-------------------|----------------------|---------------|
| Symbol                  | Parameter  | Conditions   | Typical           | Limit                | Unit s        |
|                         |  |  | ( <i>Note 6</i> ) | (Note 7)             | – (Limits)    |
|                         |  | $A_V = 1, V_{OUT} = 3V_{RMS}$  |                   |                      |               |
| THD+N                   | Total Harmonic Distortion + Noise                    | $R_L = 2k\Omega$   | 0.00003           |                      | % (max)       |
|                         |  | R <sub>L</sub> = 600Ω  | 0.00003           | 0.00009              |               |
| GBWP                    | Gain Bandwidth Product                               | $A_V = 1k, R_L = 2k$   | 25                | 19                   | MHz (min)     |
| SR                      | Slew Rate  | $R_{L} = 2k$   | ±17               | ±12                  | V/µs (min)    |
| t <sub>s</sub>          | Settling time  | $A_V = -1$ , 10V step, $C_L = 100 pF$                                    | 0.8               |                      | 110           |
| 's                      |  | 0.1% error range   | 0.0               |                      | μs            |
|                         | Equivalent Input Noise Voltage                       | f <sub>BW</sub> = 20Hz to 20kHz  | 0.7               | 1.6                  | $\mu V_{RMS}$ |
| e <sub>N</sub>          |  |  |                   |                      | (max)         |
| - IN                    | Equivalent Input Noise Density                       | f = 1kHz   | 7                 | 11                   | nV/√Hz        |
|                         |  | f = 10Hz   | 16                |                      | (max)         |
| i <sub>N</sub>          | Current Noise Density                                | f = 1kHz   | 6                 |                      | fAI∕Hz        |
| V <sub>OS</sub>         | Offset Voltage                                       |  | ±5                | ±10                  | mV (max)      |
| ΔV <sub>OS</sub> /ΔTemp | Average Input Offset Voltage Drift<br>vs Temperature | –40°C ≤ T <sub>A</sub> ≤ 85°C  | 3                 |                      | μV/°C         |
| PSRR                    | Power Supply Rejection Ratio                         | $V_{CC} = \pm 5V$ to $\pm 15V$   | 110               |                      | dB            |
| I <sub>B</sub>          | Input Bias Current                                   | $V_{CM} = 0V$  | 5                 | 150                  | pA (max)      |
| I <sub>os</sub>         | Input Offset Current                                 | $V_{CM} = 0V$  | 2                 | 100                  | pA (max)      |
| V <sub>IN-CM</sub>      | Common-Mode Input Voltage Range                      | CMRR > 55dB  | +11.5<br>-11.5    | (V+) -5V<br>(V-) +5V | V (min)       |
| CMRR                    | Common-Mode Rejection                                | -10V <vcm<10v< td=""><td>110</td><td>90</td><td>dB (min)</td></vcm<10v<> | 110               | 90                   | dB (min)      |
|                         |  | –10V <vout<10v, r<sub="">L = 600Ω</vout<10v,>                            | 115               | 100                  | dB (min)      |
| A <sub>VOL</sub>        | Open Loop Voltage Gain                               | -10V <vout<10v, <math="">R_L = 2k\Omega</vout<10v,>                      | 120               | 100                  | dB (min)      |
|                         |  | $-10V$ <vout<10v, r<sub="">L = 10k<math>\Omega</math></vout<10v,>        | 120               | 100                  | dB (min)      |
|                         | Maximum Output Voltage Swing                         | $R_{L} = 600\Omega$  | ±13.2             | ±12.0                | V (min)       |
| V <sub>OUTMAX</sub>     |  | $R_{L} = 2k\Omega$   | ±13.2             | ±12.5                | V (min)       |
|                         |  | $R_L = 10k\Omega$  | ±13.2             | ±12.5                | V (min)       |
| I <sub>OUT</sub>        | Output Current                                       | R <sub>L</sub> = 600Ω, V <sub>S</sub> = ±17V                             | ±26               |                      | mA            |
| I <sub>OUT-CC</sub>     | Instantaneous Short Circuit Current                  |  | ±48               |                      | mA            |
| R <sub>OUT</sub>        | Output Impedance                                     | f <sub>IN</sub> = 10kHz, Open-Loop                                       | 15                |                      | Ω             |
| I <sub>S</sub>          | Total Quiescent Current                              | I <sub>OUT</sub> = 0mA   | 14                | 18                   | mA (max)      |

**Note 1:** "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the Absolute Maximum Ratings or other conditions beyond those indicated in the Recommended Operating Conditions is not implied. The Recommended Operating Conditions indicate conditions at which the device is functional and the device should not be operated beyond such conditions. All voltages are measured with respect to the ground pin, unless otherwise specified.

Note 2: The *Electrical Characteristics* tables list guaranteed specifications under the listed *Recommended Operating Conditions* except as otherwise modified or specified by the *Electrical Characteristics Conditions* and/or Notes. Typical specifications are estimations only and are not guaranteed.

Note 3: Amplifier output connected to GND, any number of amplifiers within a package.

Note 4: Human body model, applicable std. JESD22-A114C.

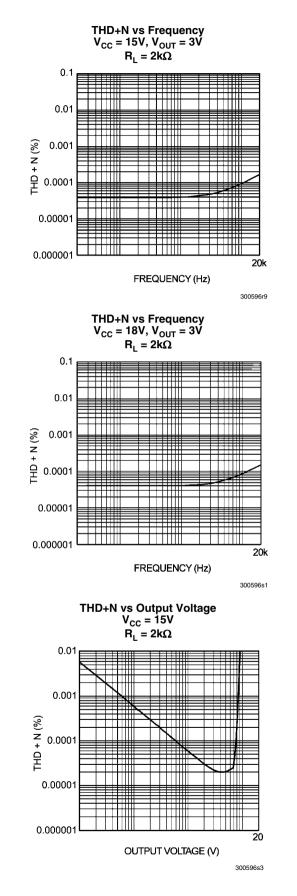
Note 5: Machine model, applicable std. JESD22-A115-A.

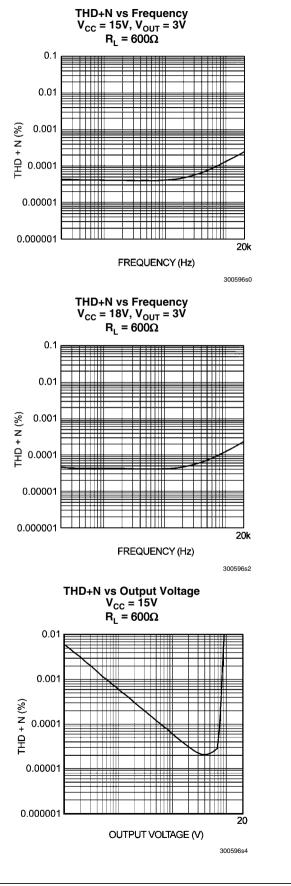
Note 6: Typical values represent most likely parametric norms at T<sub>A</sub> = +25°C, and at the *Recommended Operation Conditions* at the time of product characterization and are not guaranteed.

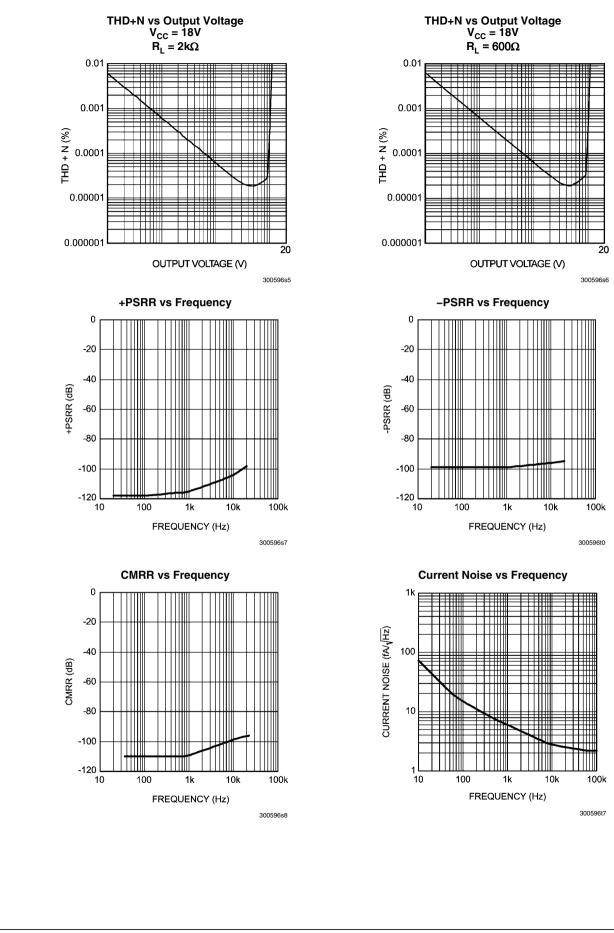
Note 7: Datasheet min/max specification limits are guaranteed by test or statistical analysis.

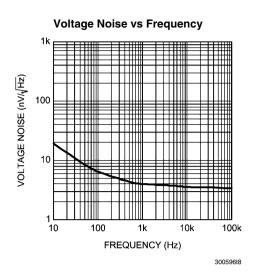
Note 8: Charge device model, applicable std JESD22-C101-A.

## **Typical Performance Characteristics**









## **Application Hints**

#### **OUTPUT DRIVE AND STABILITY**

The LME49880 is unity gain stable within the part's commonmode range. Some instabilities may occur near the limit of the common-mode range. It can drive resistive load  $600\Omega$  with output circuit with a typical 26mA. Capacitive loads up to 100pF will cause little change in the phase characteristics of the amplifiers and are therefore allowable.

Capacitive loads greater than 100pF must be isolated from the output. The most straight forward way to do this is to put a resistor in series with the output. This resistor will also prevent excess power dissipation if the output is accidentally shorted. The internal short-circuit protection of LME49880 also prevent the device from damage when the either outputs are being shorted.

The effective load impedance (including feedback resistance) should be kept above  $600\Omega$  for fast settling. Load capacitance should also be minimized if good settling time is to be optimized. Large feedback resistors will make the circuit more susceptible to stray capacitance, so in high-speed applications keep the feedback resistors in the 1k $\Omega$  to 2k $\Omega$  range whenever practical.

#### **OUTPUT COMPENSATION**

In most of the audio applications, the device will be operated in a room temperature and compensation networks are not necessary. However, the consideration of network as shown in Figure 3 may be taken into account for some of the high performance audio applications such as high speed data conversion or when operating in a relatively low junction temperature. The compensation network will also provide a small improvement in settling time for the response time demanding applications.

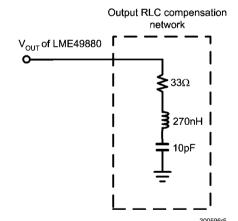
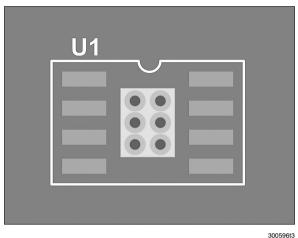


FIGURE 3: LME49880 Output Compensation Network

#### **PSOP EXPOSED PAD PACKAGE**

The LME49880 has an exposed pad on the bottom side of the IC package. Connect the exposed pad to pin 4 (V-) of the IC. The PCB footprint for the exposed pad should be a open polygon of copper to provide a good thermal path away from the LME49880. Use multiple vias on the exposed pad to create better thermal conductivity. Do not route traces below the exposed pad as they risk shorting to the exposed pad.





#### SUPPLY BYPASSING

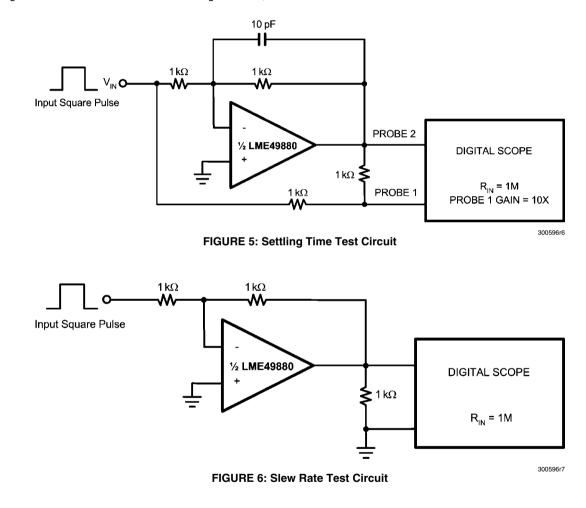
To achieve a low noise and high-speed audio performance, power supply bypassing is extremely important. Applying multiple bypass capacitors is highly recommended. From experiment results, a 10 $\mu$ F tantalum, 2.2 $\mu$ F ceramic, and a 0.47 $\mu$ F ceramic work well. All bypass capacitors leads should be very short. The ground leads of capacitors should also be separated to reduce the inductance to ground. To obtain the best result, a large ground plane layout technique is recommended and it was applied in the LME49880 evaluation board.

## **Application Information**

#### SETTLING TIME AND SLEW RATE MEASUREMENTS

The settling time of LME49880 may be verified using the test circuit in Figure 5. The LME49880 is connected for inverting operation, and the output voltage is summed with the input voltage step. When the LME49880's output voltage is equal to the input voltage, the voltage on the PROBE 1 will be zero. Any voltage appearing at this point will represent an error. And the settling time is equal to the time required for the error signal displayed on the oscilloscope to decay to less than one-half the necessary accuracy (See Settling Time – Output Swing photo). For a 10V input signal, settling time to 0.01% (1mV) will occur when the displayed error is less than 0.5mV. Since settling time is strongly dependent on slew rate, settling will be faster for smaller signal swings. The LME49880's inverting slew rate is faster than its non-inverting slew rate, so

settling will be faster for inverting applications, as well. It is important to note that the oscilloscope input amplifier may be overdriven during a settling time measurement, so the oscilloscope must be capable of recovering from overdrive very quickly. The signal generator used for this measurement must be able to drive 50 $\Omega$  with a very clean ±10V<sub>PP</sub> square wave. The Slew Rate of LME49880 tells how fast it responses to a transient or a step input. It may be measured by the test circuit in Figure 6. The Slew Rate of LME49880 is specified in closeloop gain = -1 when the output driving a  $1k\Omega$  load at  $20V_{PP}$ . The LME49880 behaves very stable in shape step response and have a minimal ringing in both small and large signal step response (See Typical Performance Characteristic). The slew rate typical value reach as high as ±18V/µS was measured when the output reach -20V refer to the start point when input voltage equals to zero.



#### **DISTORTION MEASUREMENTS**

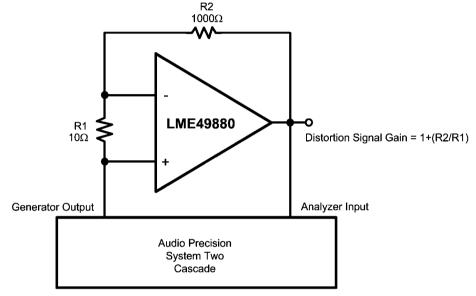
The vanishingly low residual distortion produced by LME49880 is below the capabilities of all commercially available equipment. This makes distortion measurements just slightly more difficult than simply connecting a distortion meter to the amplifier's inputs and outputs. The solution, however, is quite simple: an additional resistor. Adding this resistor extends the resolution of the distortion measurement equipment.

The LME49880's low residual distortion is an input referred internal error. As shown in Figure 7, adding the  $10\Omega$  resistor connected between the amplifier's inverting and non-inverting inputs changes the amplifier's noise gain. The result is that

the error signal (distortion) is amplified by a factor of 101. Although the amplifier's closed-loop gain is unaltered, the feedback available to correct distortion errors is reduced by 101, which means that measurement resolution increases by 101. To ensure minimum effects on distortion measurements, keep the value of R1 low as shown in Figure 7.

This technique is verified by duplicating the measurements with high closed loop gain and/or making the measurements at high frequencies. Doing so produces distortion components that are within the measurement equipment's capabilities. This datasheet's THD+N and IMD values were generated using the above described circuit connected to an Audio Precision System Two Cascade.

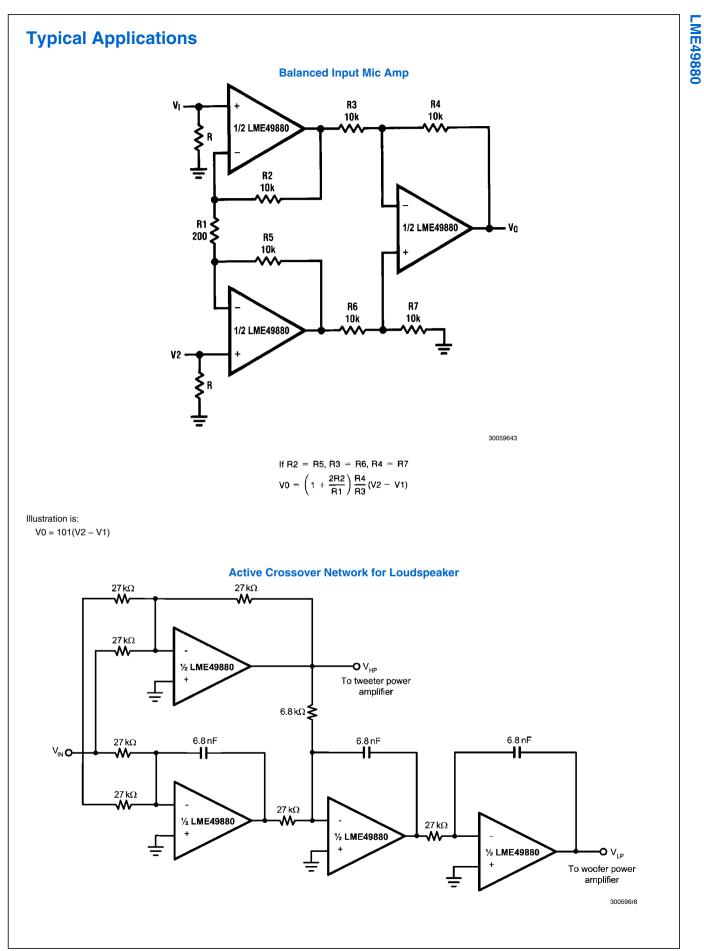
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Actual Distortion = AP Value/100

FIGURE 7: THD+N and IMD Distortion Test Circuit

LME49880



# **Revision History**

| Rev             | Date                           | Description   |
|-----------------|--------------------------------|---|
| 1.0             | 1.0 12/16/09 Initial released. |   |
| 1.01            | 01/08/10                       | Input text edits.   |
| 1 02   03/22/10 |                                | Edited the scaling (Y-axis) on the THD+N curves to match the limits described in the datasheet. |

#### Physical Dimensions inches (millimeters) unless otherwise noted (.122) [3.1] <u>B</u>-.193±.004 [4.9±0.1] зүмм -EXPOSED PAD AT BOTTOM Ç (.219) [5.56] .095 [2.41] SYMM ⊄ (.095))| [2.41].154±.004 [3.9±0.1] .230-.244 075 911 (8) -(8X.024) [0.61] PIN 1 ID-(6X .050 )-[1.27] (,122) -[3.1] RECOMMENDED LAND PATTERN 6X .050 [1.27] 45°X .013 [0.33] .056-.066 [1.42-1.68] ( 058 ) [1.47] A 0° - 8 .004 [0.1] A 8X -.0075-.0098 [0.19-0.25] 8X .0138-.0192 → [0.35-0.49] (⊕ .010 [0.25]) A B (C) .001-.005 [0.025-0.127] TYP .016-.035 [0.42-0.89] (.040) [1.01] CONTROLLING DIMENSION IS INCH VALUES IN [] ARE MILLIMETERS DIMENSIONS IN ( ) FOR REFERENCE ONLY MRA08B (Rev B) Narrow PSOP Package Order Number LME49880MR NS Package Number MRA08B

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|  | OMAP Mobile Processors | www.ti.com/omap                 |                               |                                   |
|  | Wireless Connectivity  | www.ti.com/wirelessconnectivity |                               |                                   |
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