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ON Semiconductor®

# LMV321 / LMV358 / LMV324

## General-Purpose, Low Voltage, Rail-to-Rail Output Amplifiers

### Features at +2.7V

- 80  $\mu\text{A}$  Supply Current per Channel
- 1.2 MHz Gain Bandwidth Product
- Output Voltage Range: 0.01 V to 2.69 V
- Input Voltage Range: -0.25 V to +1.5 V
- 1.5 V/ $\mu\text{s}$  Slew Rate
- LMV321 Directly Replaces Other Industry Standard LMV321 Amplifiers: Available in SC70-5 and SOT23-5 Packages
- LMV358 Directly Replaces Other Industry Standard LMV358 Amplifiers: Available in MSOP-8 and SOIC-8 Packages
- LMV324 Directly Replaces Other Industry Standard LMV324 Amplifiers: Available in SOIC-14 Packages
- Fully Specified at +2.7 V and +5 V Supplies
- Operating Temperature Range: -40°C to +125°C

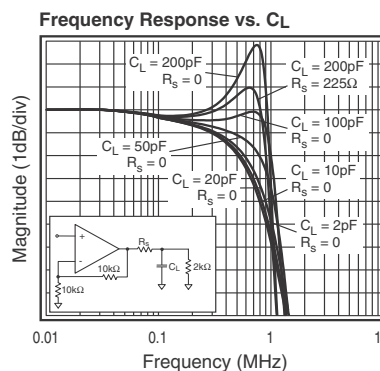
### Applications

- Low Cost General-Purpose Applications
- Cellular Phones
- Personal Data Assistants
- A/D Buffer
- DSP Interface
- Smart Card Readers
- Portable Test Instruments
- Keyless Entry
- Infrared Receivers for Remote Controls
- Telephone Systems
- Audio Applications
- Digital Still Cameras
- Hard Disk Drives
- MP3 Players

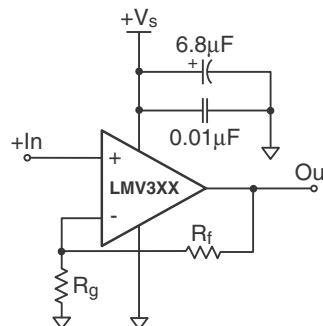
### Description

The LMV321 (single), LMV358 (dual), and LMV324 (quad) are a low cost, voltage feedback amplifiers that consume only 80  $\mu\text{A}$  of supply current per amplifier. The LMV3XX family is designed to operate from 2.7 V ( $\pm 1.35$  V) to 5.5 V ( $\pm 2.75$  V) supplies. The common mode voltage range extends below the negative rail and the output provides rail-to-rail performance.

The LMV3XX family is designed on a CMOS process and provides 1.2 MHz of bandwidth and 1.5 V/ $\mu\text{s}$  of slew rate at a low supply voltage of 2.7 V. The combination of low power, rail-to-rail performance, low voltage operation, and tiny pack-age options make the LMV3XX family well suited for use in personal electronics equipment such as cellular handsets, pagers, PDAs, and other battery powered applications.



### Typical Application

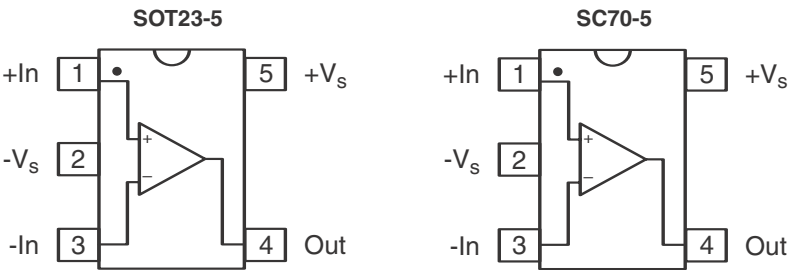


### Ordering Information

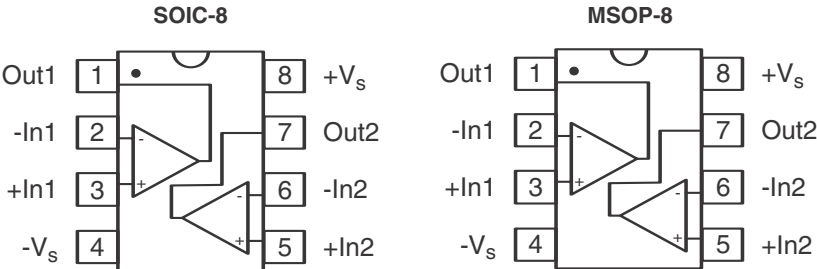
| Product Number | Package          | Packing Method         | Operating Temperature |
|----------------|------------------|------------------------|-----------------------|
| LMV321AP5X     | SC70 5L          | Tape and Reel, 3000pcs | -40 to +125°C         |
| LMV321AS5X     | SOT-23 5L        | Tape and Reel, 3000pcs |                       |
| LMV358AM8X     | SOIC 8L (Narrow) | Tape and Reel, 2500pcs |                       |
| LMV358AMU8X    | MSOP 8L          | Tape and Reel, 3000pcs |                       |
| LMV324AM14X    | SOIC 14L         | Tape and Reel, 2500pcs |                       |

### Pin Assignments

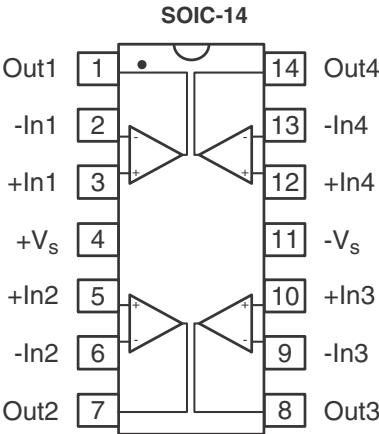
#### LMV321



#### LMV358



#### LMV324



## Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

| Parameter                    | Min.         | Max.         | Unit |
|------------------------------|--------------|--------------|------|
| Supply Voltage               | 0            | +6           | V    |
| Maximum Junction Temperature | -            | +175         | °C   |
| Storage Temperature Range    | -65          | +150         | °C   |
| Lead Temperature, 10 Seconds | -            | +260         | °C   |
| Input Voltage Range          | $-V_S - 0.5$ | $+V_S + 0.5$ | V    |

## Recommended Operating Conditions

| Parameter                    | Min. | Max. | Unit |
|------------------------------|------|------|------|
| Operating Temperature Range  | -40  | +125 | °C   |
| Power Supply Operating Range | 2.5  | 5.5  | V    |

## Package Thermal Resistance

| Package      | $\theta_{JA}$ | Unit |
|--------------|---------------|------|
| 5 Lead SC70  | 331.4         | °C/W |
| 5 Lead SOT23 | 256           | °C/W |
| 8 Lead SOIC  | 152           | °C/W |
| 8 Lead MSOP  | 206           | °C/W |
| 14 Lead SOIC | 88            | °C/W |

## Electrical Specifications

$T_C = 25^\circ\text{C}$ ,  $V_S = +2.7\text{ V}$ ,  $G = 2$ ,  $R_L = 10\text{ k}\Omega$  to  $V_S/2$ ,  $R_f = 10\text{ k}\Omega$ ,  $V_{O(DC)} = V_{CC}/2$ , unless otherwise noted.

| Parameter                                      |        | Conditions                                                         | Min. | Typ.  | Max. | Unit   |
|------------------------------------------------|--------|--------------------------------------------------------------------|------|-------|------|--------|
| AC Performance                                 |        |                                                                    |      |       |      |        |
| Gain Bandwidth Product                         |        | C <sub>L</sub> = 50 pF, R <sub>L</sub> = 2 kΩ to V <sub>S</sub> /2 |      | 1.2   |      | MHz    |
| Phase Margin                                   |        |                                                                    |      | 52    |      | deg    |
| Gain Margin                                    |        |                                                                    |      | 17    |      | dB     |
| Slew Rate                                      |        | V <sub>O</sub> = 1V <sub>PP</sub>                                  |      | 1.5   |      | V/μs   |
| Input Voltage Noise                            |        | >50 kHz                                                            |      | 36    |      | nV/√Hz |
| Crosstalk                                      | LMV358 | 100 kHz                                                            |      | 91    |      | dB     |
|                                                | LMV324 | 100 kHz                                                            |      | 80    |      |        |
| DC Performance                                 |        |                                                                    |      |       |      |        |
| Input Offset Voltage <sup>(1)</sup>            |        |                                                                    |      | 1.7   | 7.0  | mV     |
| Average Drift                                  |        |                                                                    |      | 8     |      | μV/°C  |
| Input Bias Current <sup>(2)</sup>              |        |                                                                    |      | <1    |      | nA     |
| Input Offset Current <sup>(2)</sup>            |        |                                                                    |      | <1    |      | nA     |
| Power Supply Rejection Ratio <sup>(1)</sup>    |        | DC                                                                 | 50   | 65    |      | dB     |
| Supply Current (Per Channel) <sup>(1)</sup>    |        |                                                                    |      | 80    | 120  | μA     |
| Input Characteristics                          |        |                                                                    |      |       |      |        |
| Input Common Mode Voltage Range <sup>(1)</sup> |        | LO                                                                 | 0    | -0.25 |      | V      |
|                                                |        | HI                                                                 |      | 1.5   | 1.3  |        |
| Common Mode Rejection Ratio <sup>(1)</sup>     |        |                                                                    | 50   | 70    |      | dB     |
| Output Characteristics                         |        |                                                                    |      |       |      |        |
| Output Voltage Swing                           |        | R <sub>L</sub> = 10 kΩ to V <sub>S</sub> /2; LO <sup>(1)</sup>     |      | 0.01  | 0.10 | V      |
|                                                |        | R <sub>L</sub> = 10 kΩ to V <sub>S</sub> /2; HI <sup>(1)</sup>     | 2.60 | 2.69  |      |        |

Min/max ratings are based on product characterization and simulation. Individual parameters are tested as noted. Outgoing quality levels are determined from tested parameters.

### Notes:

1. Guaranteed by testing or statistical analysis at  $+25^\circ\text{C}$ .
2. +IN and -IN are gates to CMOS transistors with typical input bias current of <1 nA. CMOS leakage is too small to practically measure.

**Electrical Specifications** (Continued)

$T_C = 25^\circ\text{C}$ ,  $V_S = +5\text{ V}$ ,  $G = 2$ ,  $R_L = 10\text{ k}\Omega$  to  $V_S/2$ ,  $R_f = 10\text{ k}\Omega$ ,  $V_{O(DC)} = V_{CC}/2$ , unless otherwise noted.

| Parameter                                      |                                                          | Conditions                                                 | Min. | Typ.           | Max.  | Unit                         |
|------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------|------|----------------|-------|------------------------------|
| <b>AC Performance</b>                          |                                                          |                                                            |      |                |       |                              |
| Gain Bandwidth Product                         |                                                          | $C_L = 50\text{ pF}$ , $R_L = 2\text{ k}\Omega$ to $V_S/2$ |      | 1.4            |       | MHz                          |
| Phase Margin                                   |                                                          |                                                            |      | 73             |       | deg                          |
| Gain Margin                                    |                                                          |                                                            |      | 12             |       | dB                           |
| Slew Rate                                      |                                                          |                                                            |      | 1.5            |       | V/ $\mu\text{s}$             |
| Input Voltage Noise                            |                                                          | $>50\text{ kHz}$                                           |      | 33             |       | nV/ $\sqrt{\text{Hz}}$       |
| Crosstalk                                      | LMV358                                                   | 100 kHz                                                    |      | 91             |       | dB                           |
|                                                | LMV324                                                   | 100 kHz                                                    |      | 80             |       | dB                           |
| <b>DC Performance</b>                          |                                                          |                                                            |      |                |       |                              |
| Input Offset Voltage <sup>(3)</sup>            |                                                          |                                                            |      | 1              | 7     | mV                           |
| Average Drift                                  |                                                          |                                                            |      | 6              |       | $\mu\text{V}/^\circ\text{C}$ |
| Input Bias Current <sup>(4)</sup>              |                                                          |                                                            |      | $<1$           |       | nA                           |
| Input Offset Current <sup>(4)</sup>            |                                                          |                                                            |      | $<1$           |       | nA                           |
| Power Supply Rejection Ratio <sup>(3)</sup>    |                                                          | DC                                                         | 50   | 65             |       | dB                           |
| Open Loop Gain <sup>(3)</sup>                  |                                                          |                                                            | 50   | 70             |       | dB                           |
| Supply Current (Per Channel) <sup>(3)</sup>    |                                                          |                                                            |      | 100            | 150   | $\mu\text{A}$                |
| <b>Input Characteristics</b>                   |                                                          |                                                            |      |                |       |                              |
| Input Common Mode Voltage Range <sup>(3)</sup> | LO                                                       |                                                            | 0    | -0.4           |       | V                            |
|                                                | HI                                                       |                                                            |      | 3.8            | 3.6   | V                            |
| Common Mode Rejection Ratio <sup>(3)</sup>     |                                                          |                                                            | 50   | 75             |       | dB                           |
| <b>Output Characteristics</b>                  |                                                          |                                                            |      |                |       |                              |
| Output Voltage Swing                           | $R_L = 2\text{ k}\Omega$ to $V_S/2$ ; LO/HI              |                                                            |      | 0.036 to 4.950 |       | V                            |
|                                                | $R_L = 10\text{ k}\Omega$ to $V_S/2$ ; LO <sup>(3)</sup> |                                                            |      | 0.013          | 0.100 | V                            |
|                                                | $R_L = 10\text{ k}\Omega$ to $V_S/2$ ; HI <sup>(3)</sup> |                                                            | 4.90 | 4.98           |       | V                            |
| Short Circuit Output Current <sup>(3)</sup>    | Sourcing; $V_O = 0\text{ V}$                             |                                                            | 5    | +34            |       | mA                           |
|                                                | Sinking; $V_O = 5\text{ V}$                              |                                                            | 10   | -23            |       | mA                           |

Min/max ratings are based on product characterization and simulation. Individual parameters are tested as noted. Outgoing quality levels are determined from tested parameters.

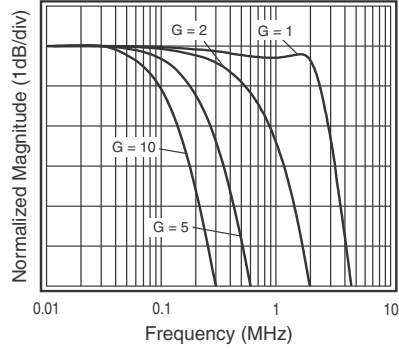
**Notes:**

- Guaranteed by testing or statistical analysis at  $+25^\circ\text{C}$ .
- +IN and -IN are gates to CMOS transistors with typical input bias current of  $<1\text{ nA}$ . CMOS leakage is too small to practically measure.

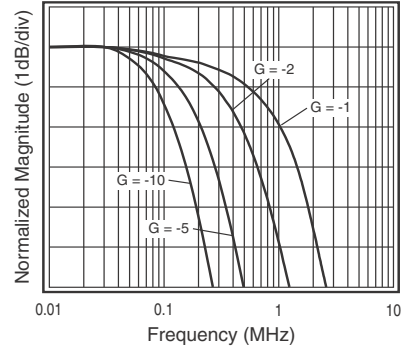
## Typical Operating Characteristics

$T_C = 25^\circ\text{C}$ ,  $V_S = +5\text{ V}$ ,  $G = 2$ ,  $R_L = 10\text{ k}\Omega$  to  $V_S/2$ ,  $R_f = 10\text{ k}\Omega$ ,  $V_{O(DC)} = V_{CC}/2$ , unless otherwise noted.

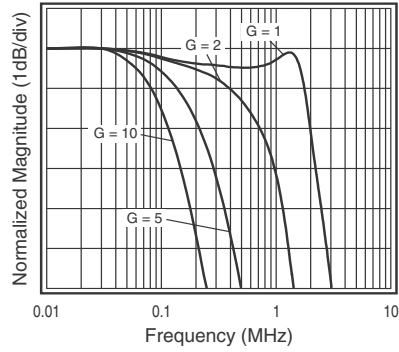
Non-Inverting Freq. Response  $V_S = +5\text{V}$



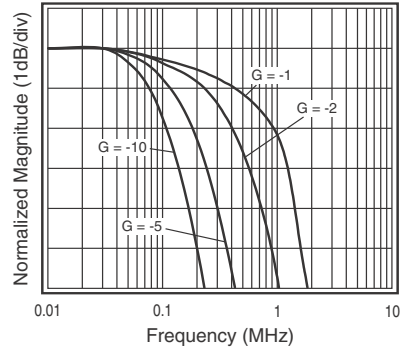
Inverting Frequency Response  $V_S = +5\text{V}$



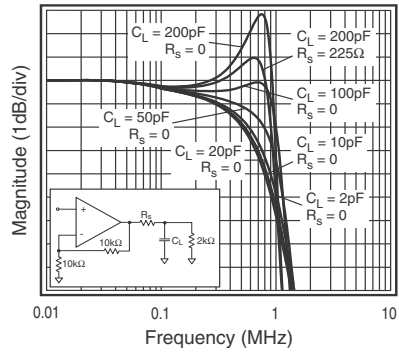
Non-Inverting Freq. Response  $V_S = +2.7\text{V}$



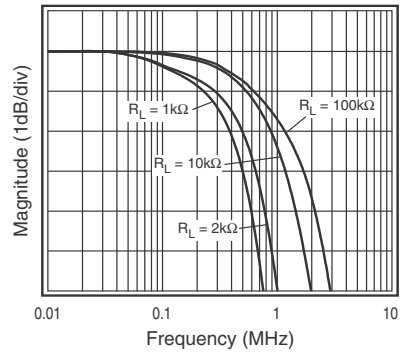
Inverting Freq. Response  $V_S = +2.7\text{V}$



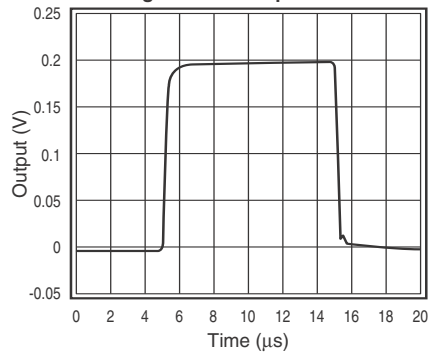
Frequency Response vs.  $C_L$



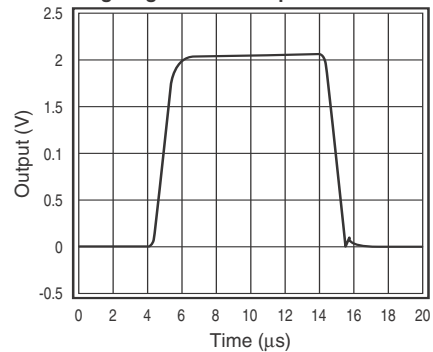
Frequency Response vs.  $R_L$



Small Signal Pulse Response

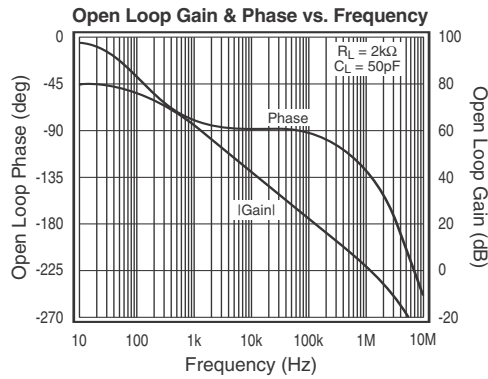
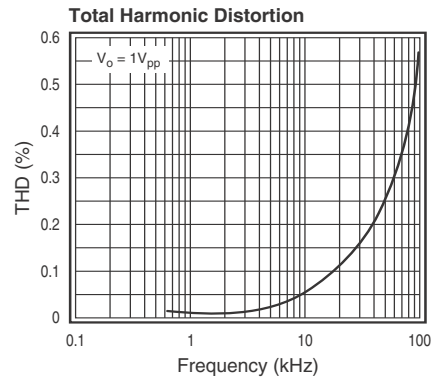
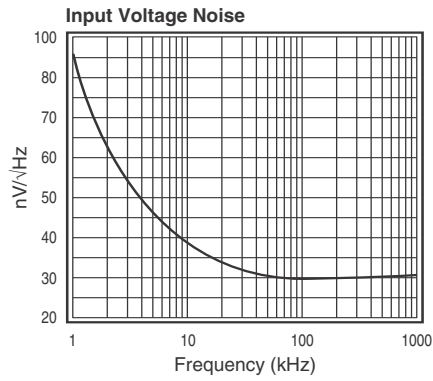


Large Signal Pulse Response



## Typical Operating Characteristics (Continued)

$T_C = 25^\circ\text{C}$ ,  $V_S = +5\text{ V}$ ,  $G = 2$ ,  $R_L = 10\text{ k}\Omega$  to  $V_S/2$ ,  $R_f = 10\text{ k}\Omega$ ,  $V_{O(\text{DC})} = V_{CC}/2$ , unless otherwise noted.





## Application Information

### General Description

The LMV3XX family are single supply, general-purpose, voltage-feedback amplifiers that are pin-for-pin compatible and drop in replacements with other industry standard LMV321, LMV358, and LMV324 amplifiers. The LMV3XX family is fabricated on a CMOS process, features a rail-to-rail output, and is unity gain stable.

The typical non-inverting circuit schematic is shown in Figure 1.

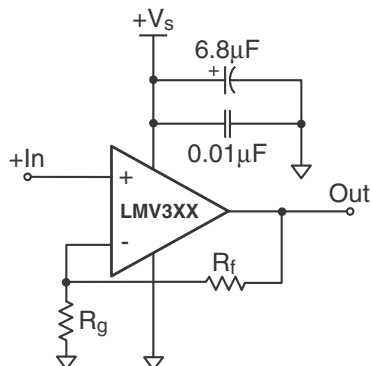


Figure 1. Typical Non-inverting configuration

### Power Dissipation

The maximum internal power dissipation allowed is directly related to the maximum junction temperature. If the maximum junction temperature exceeds 150°C, some performance degradation will occur. If the maximum junction temperature exceeds 175°C for an extended time, device failure may occur.

### Driving Capacitive Loads

The **Frequency Response vs.  $C_L$**  plot on page 4, illustrates the response of the LMV3XX family. A small series resistance ( $R_S$ ) at the output of the amplifier, illustrated in Figure 2, will improve stability and settling performance.  $R_S$  values in the **Frequency Response vs.  $C_L$**  plot were chosen to achieve maximum bandwidth with less than 1dB of peaking. For maximum flatness, use a larger  $R_S$ . As the plot indicates, the LMV3XX family can easily drive a 200 pF capacitive load without a series resistance. For comparison, the plot also shows the LMV321 driving a 200 pF load with a 225  $\Omega$  series resistance.

Driving a capacitive load introduces phase-lag into the output signal, which reduces phase margin in the amplifier. The unity gain follower is the most sensitive configuration. In a unity gain follower configuration, the LMV3XX family requires a 450  $\Omega$  series resistor to drive a 200 pF load. The response is illustrated in Figure 3.

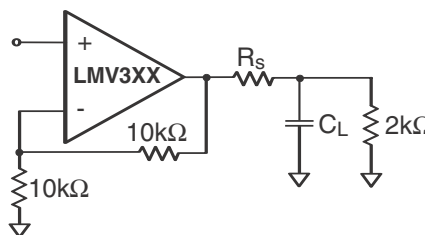


Figure 2. Typical Topology for driving a capacitive load

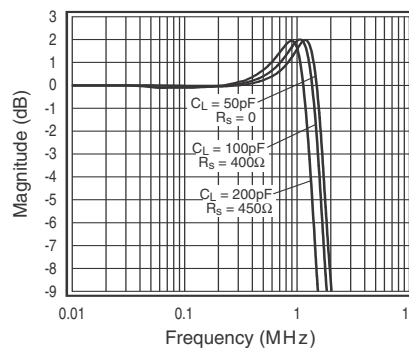


Figure 3. Frequency Response vs.  $C_L$  for unity gain configuration

### Layout Considerations

General layout and supply bypassing play major roles in high frequency performance. ON Semiconductor has evaluation boards to use as a guide for high frequency layout and as aid in device testing and characterization. Follow the steps below as a basis for high frequency layout:

- Include 6.8  $\mu\text{F}$  and 0.01  $\mu\text{F}$  ceramic capacitors
- Place the 6.8  $\mu\text{F}$  capacitor within 0.75 inches of the power pin
- Place the 0.01  $\mu\text{F}$  capacitor within 0.1 inches of the power pin
- Remove the ground plane under and around the part, especially near the input and output pins to reduce parasitic capacitance
- Minimize all trace lengths to reduce series inductances

Refer to the evaluation board layouts shown in Figure 5 on page 8 for more information.

### Evaluation Board Information

The following evaluation boards are NOT available any more but their Schematic & Layout information will be useful for references to aid in the testing and layout of this device.

| Eval Bd | Description                                                  | Products    |
|---------|--------------------------------------------------------------|-------------|
| KEB013  | Single Channel, Dual Supply, SOT23-5 for Buffer-Style Pinout | LMV321AS5X  |
| KEB014  | Single Channel, Dual Supply, SC70-5 for Buffer-Style Pinout  | LMV321AP5X  |
| KEB006  | Dual Channel, Dual Supply, 8 Lead SOIC                       | LMV358AM8X  |
| KEB010  | Dual Channel, Dual Supply, 8 Lead MSOP                       | LMV358AMU8X |
| KEB018  | Quad Channel, Dual Supply, 14 Lead SOIC                      | LMV324AM14X |

Evaluation board schematics and layouts are shown in Figures 4 and 5.

### Evaluation Board Schematic Diagrams

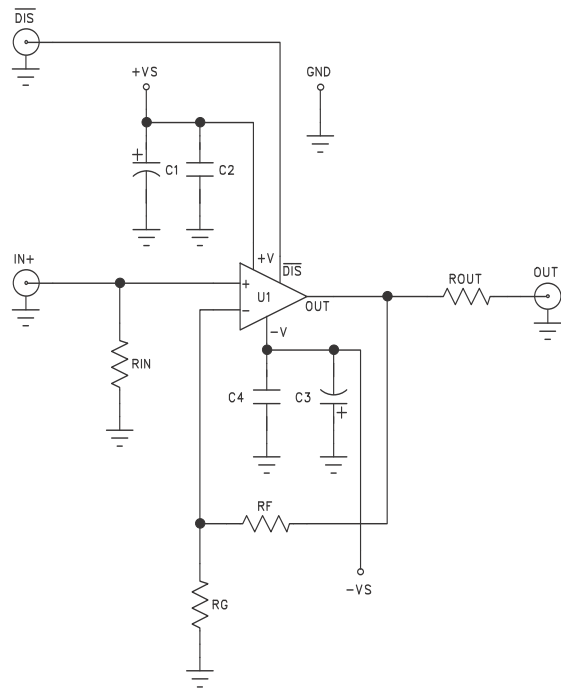


Figure 4a. LMV321 KEB013 schematic

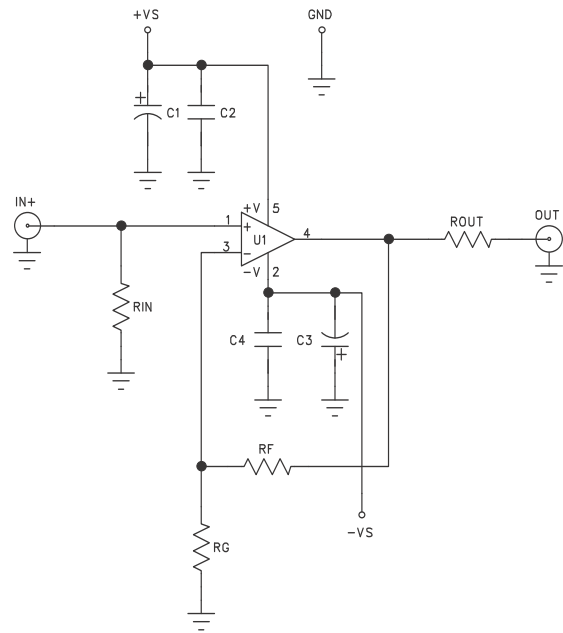


Figure 4b. LMV321 KEB014 schematic

# Evaluation Board Schematic Diagrams (Continued)

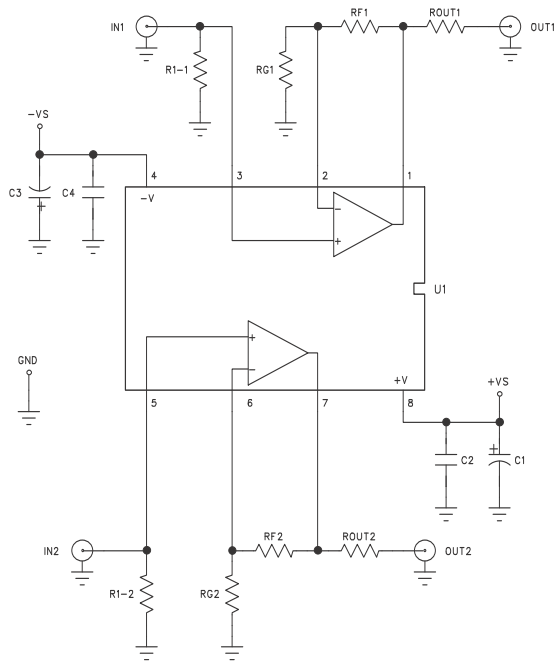


Figure 4c. LMV358 KEB006/KEB010 schematic

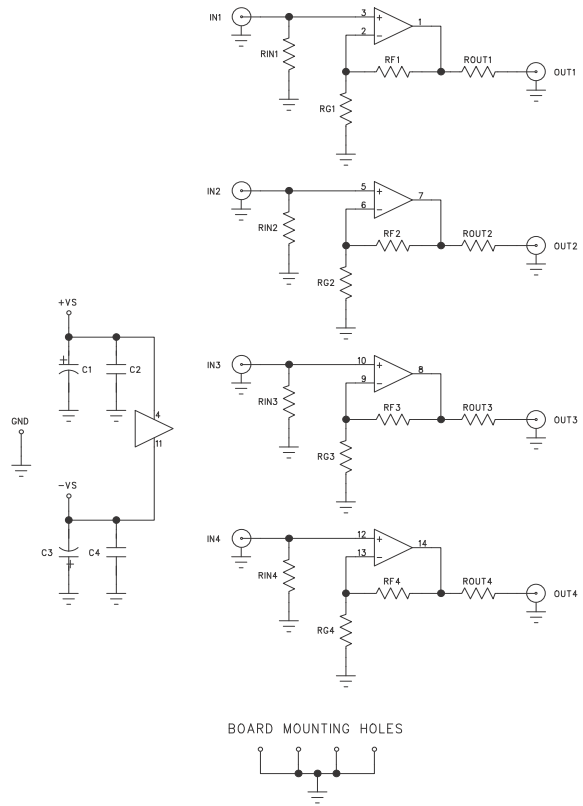


Figure 4d. LMV324 KEB018 schematic

## LMV321 Evaluation Board Layout

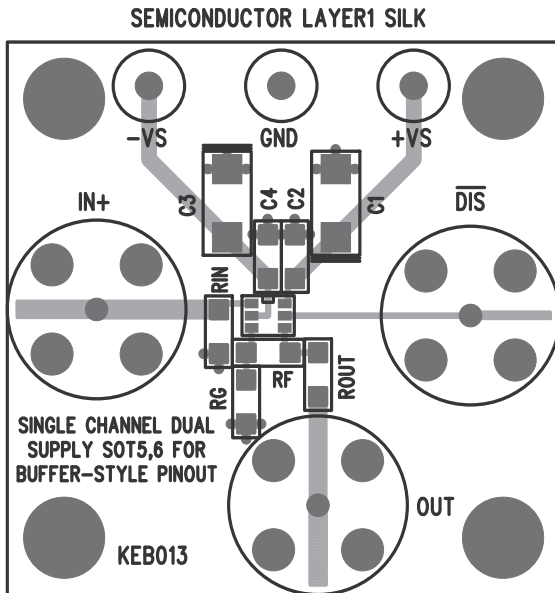


Figure 5a. KEB013 (top side)

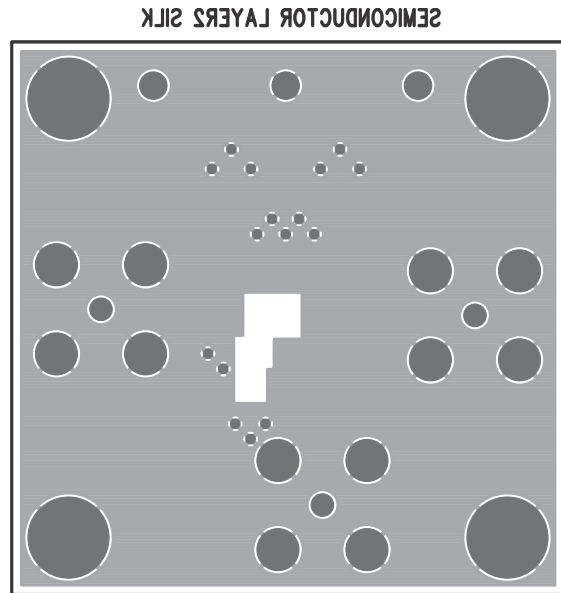


Figure 5b. KEB013 (bottom side)

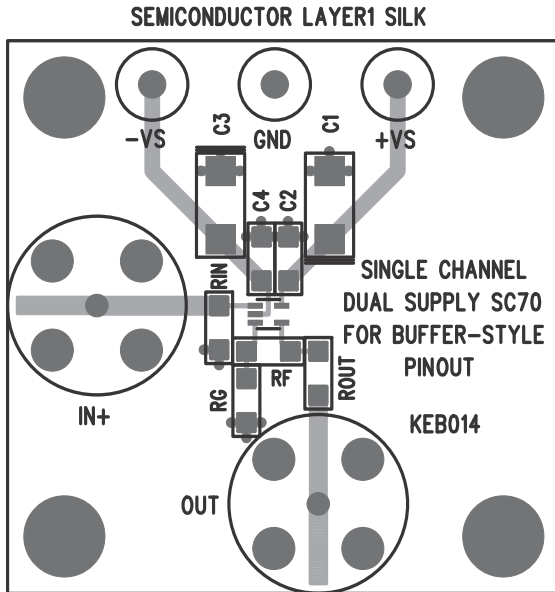


Figure 5c. KEB014 (top side)

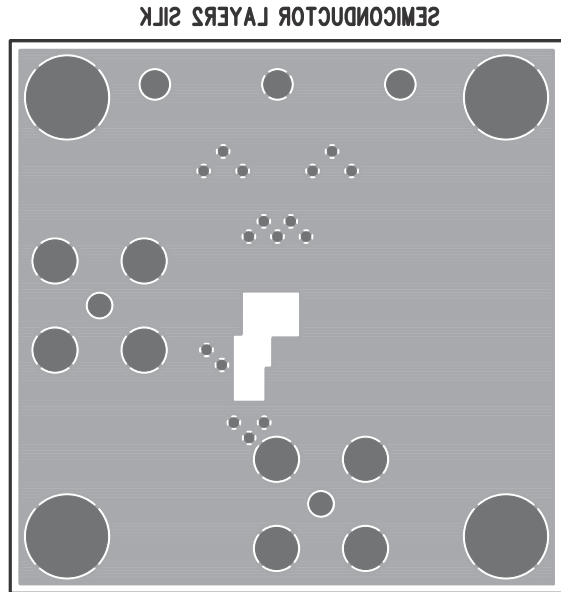


Figure 5d. KEB014 (bottom side)

## LMV358 Evaluation Board Layout

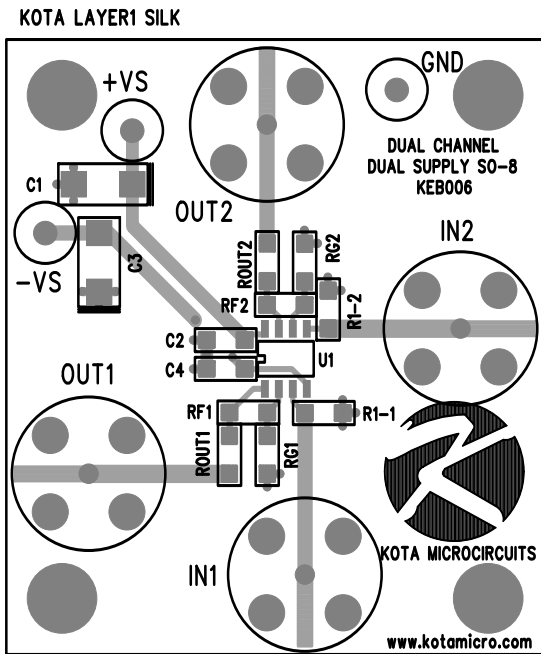


Figure 5e. KEB006 (top side)

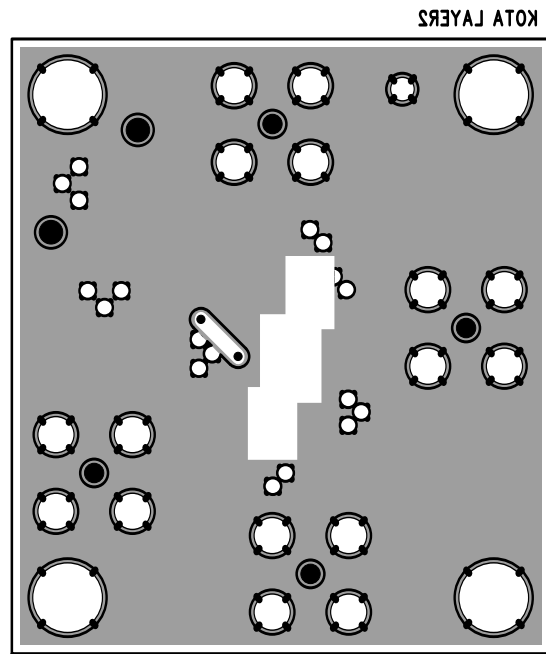


Figure 5f. KEB006 (bottom side)

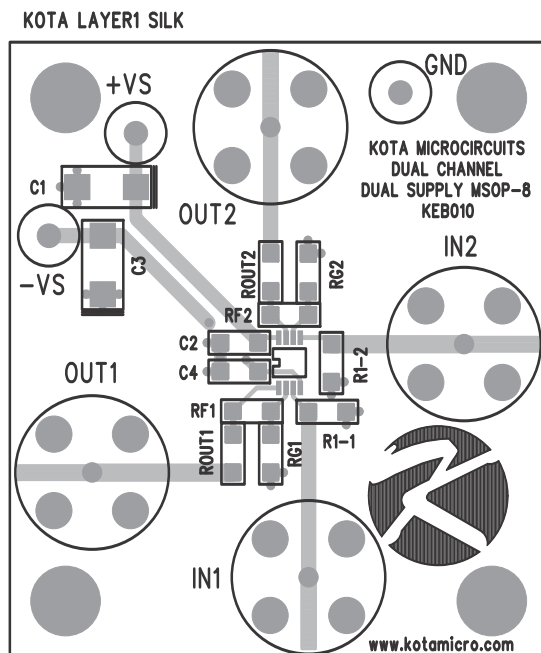


Figure 5g. KEB010 (top side)

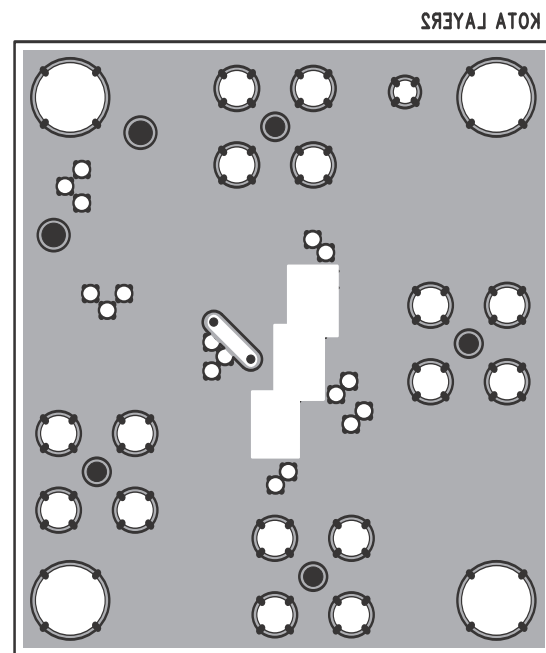


Figure 5h. KEB010 (bottom side)

LMV324 Evaluation Board Layout

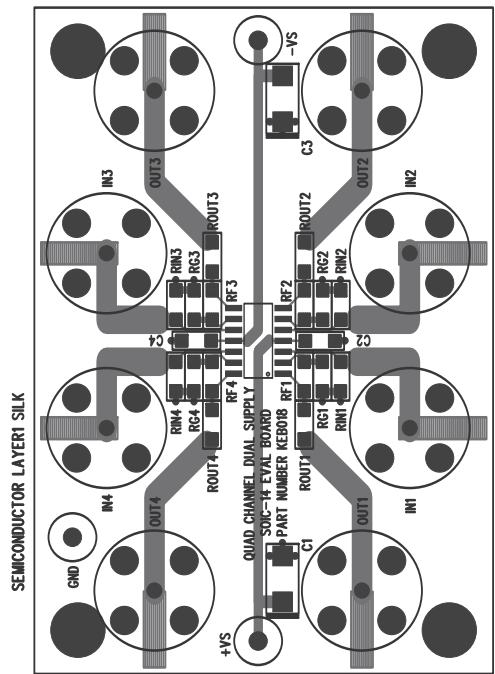


Figure 5i. KEB018 (top side)

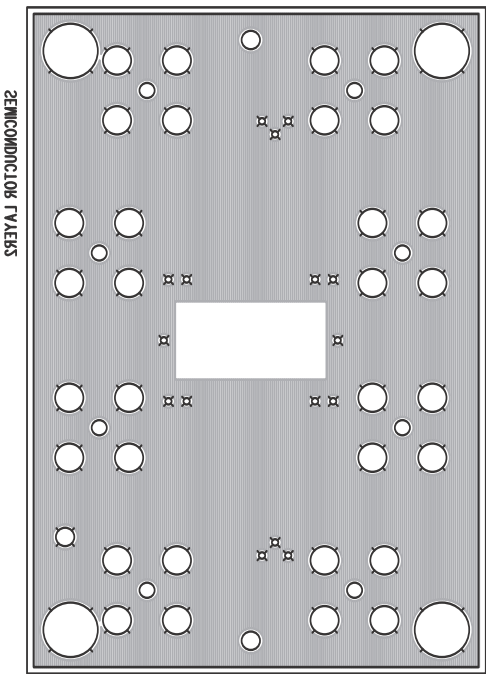
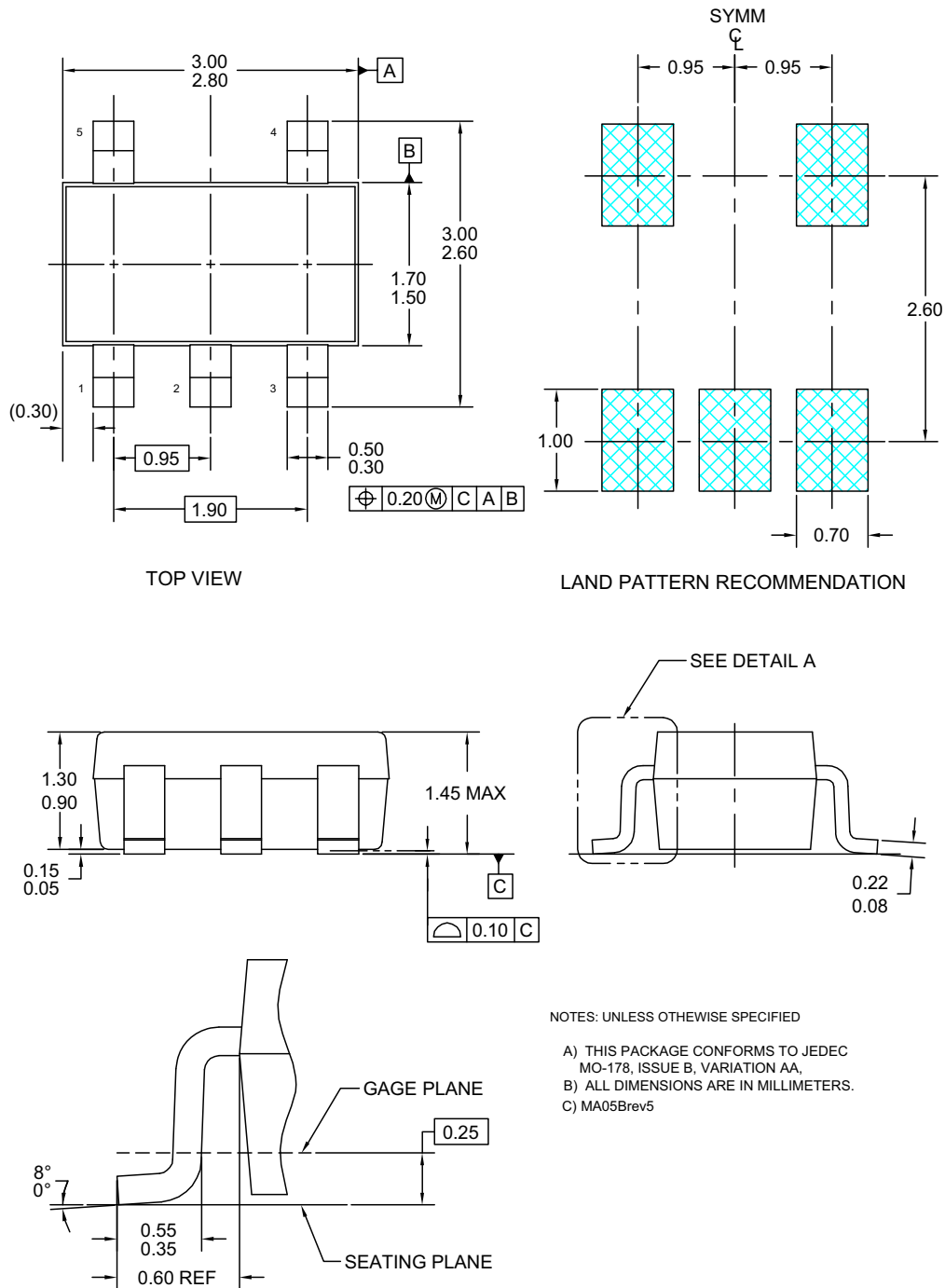
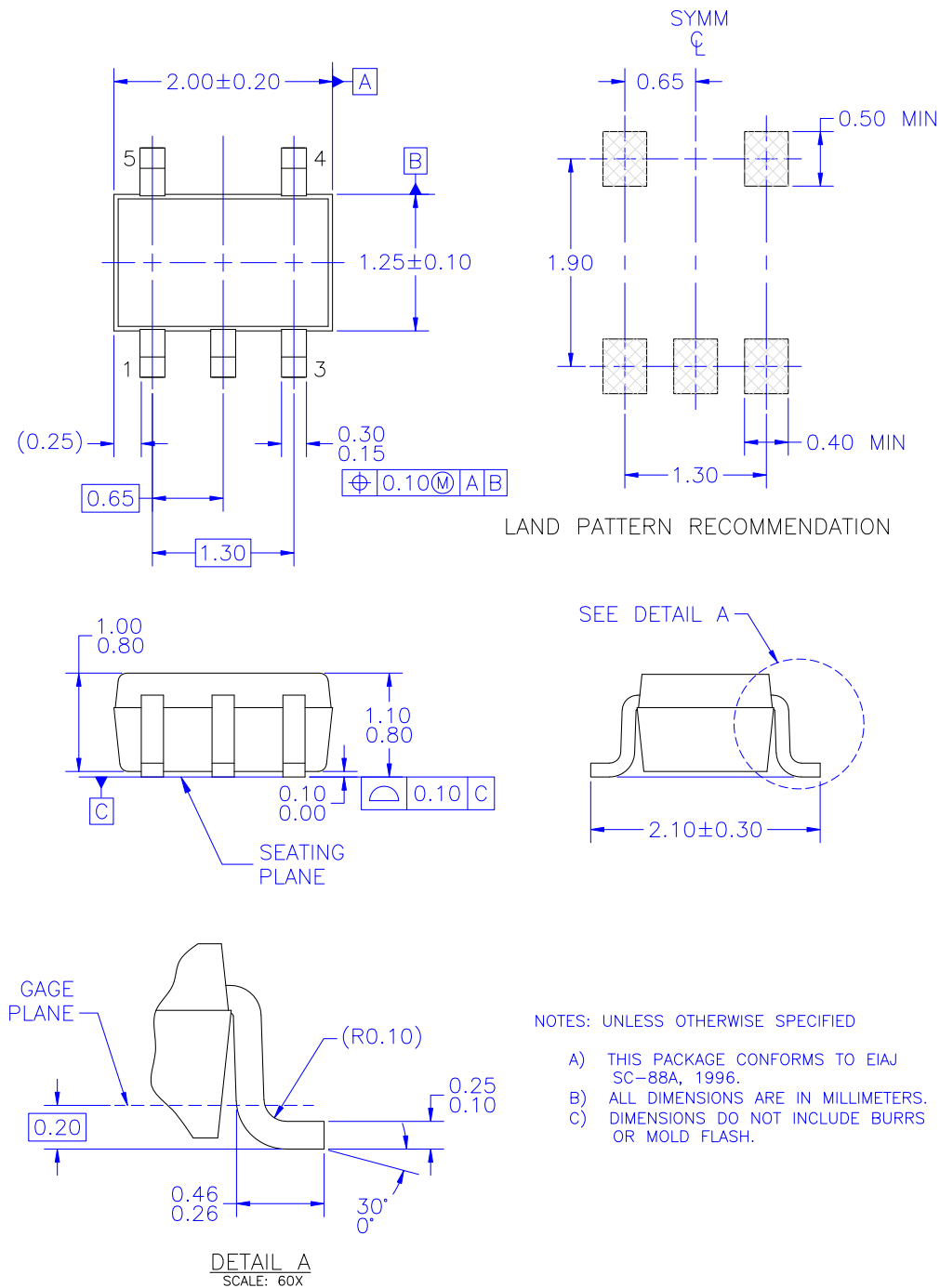


Figure 5j. KEB018 (bottom side)

## Physical Dimensions



# Physical Dimensions (Continued)



MAA05AREV5

**Figure 7. 5-LEAD, SC70, EIAJ SC-88A, 1.25MM WIDE**



# Physical Dimensions (Continued)

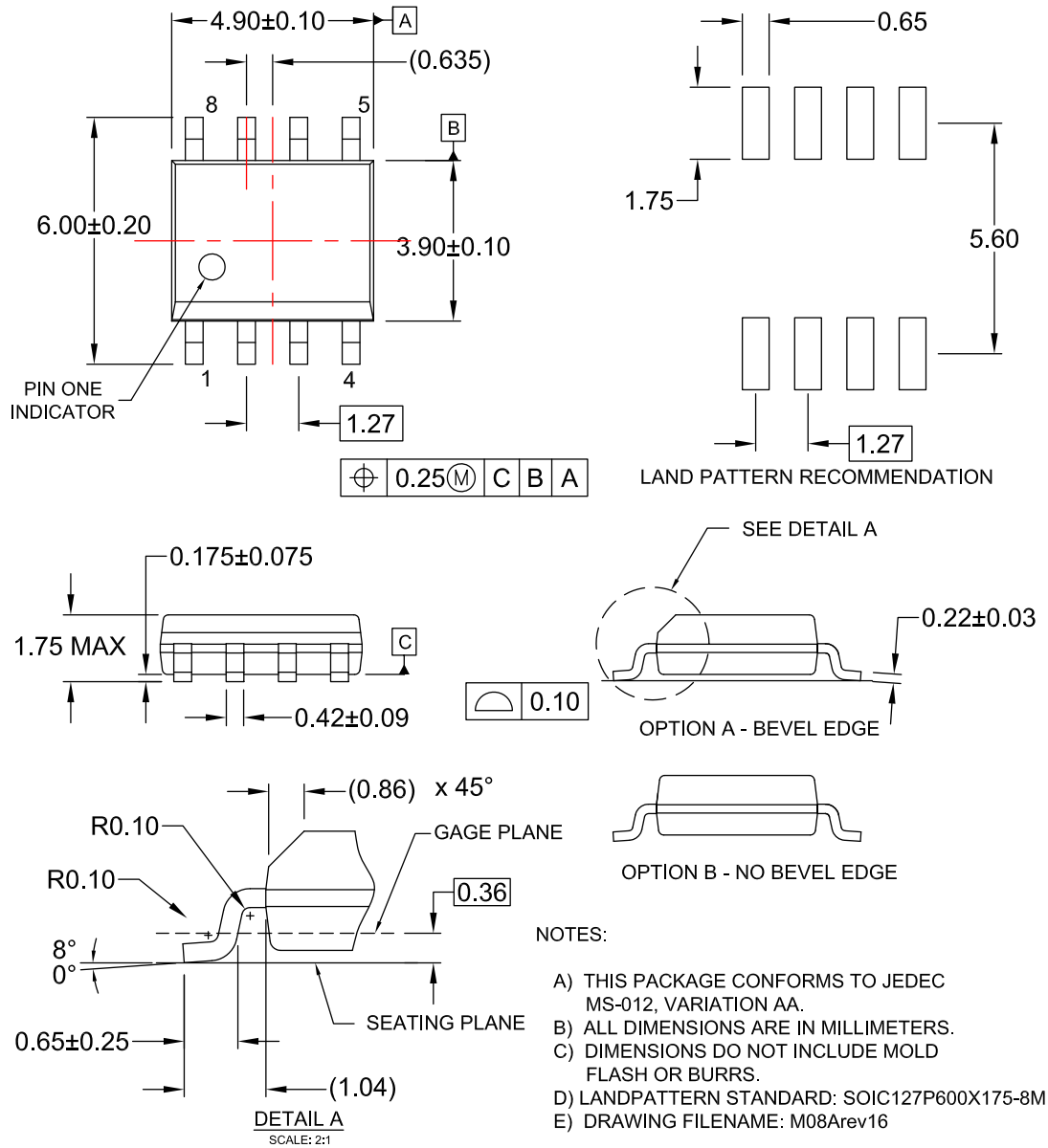


Figure 8. 8-LEAD, SOIC, JEDEC MS-012, 0.150 INCH NARROW BODY

# Physical Dimensions (Continued)

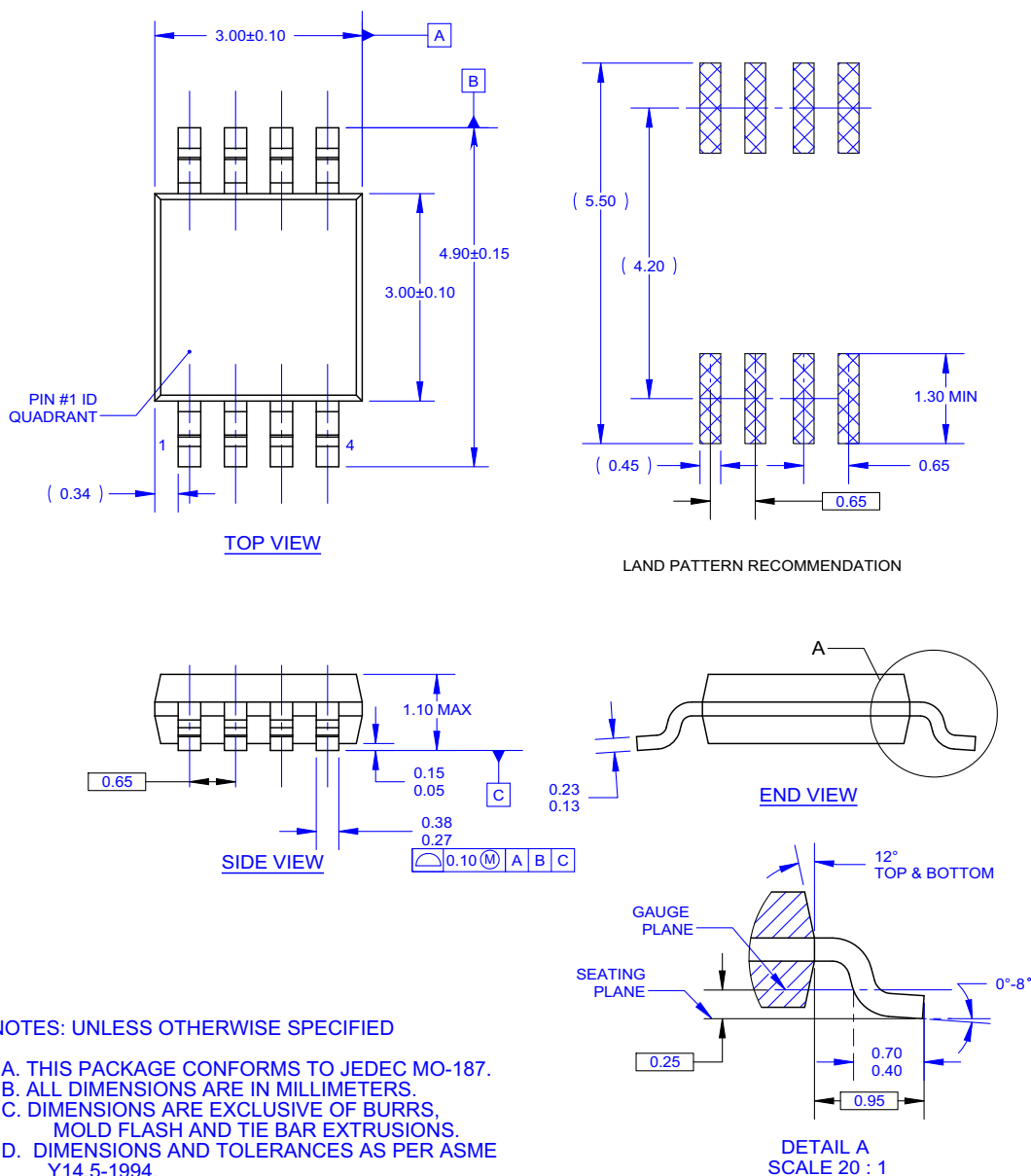
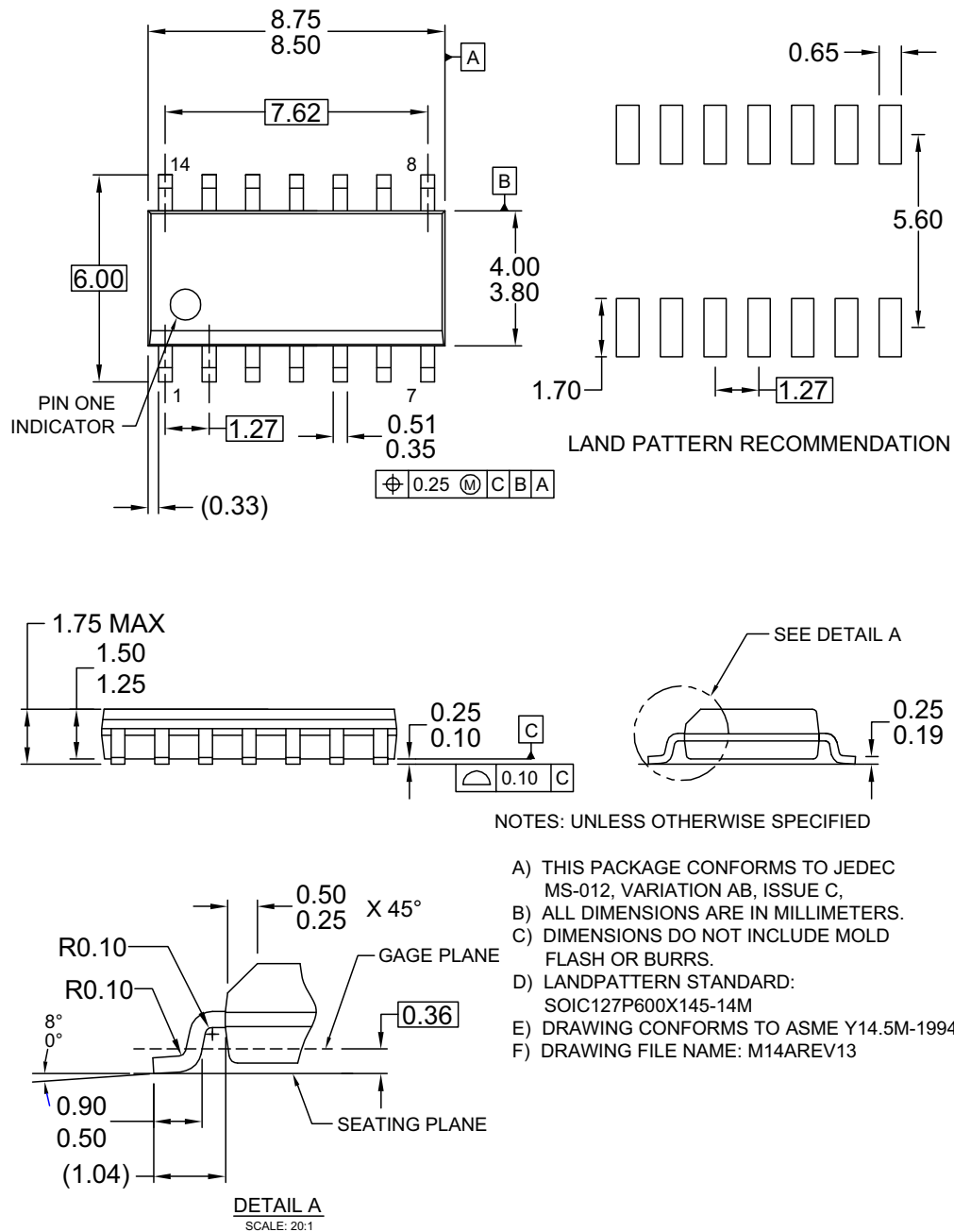


Figure 9. 8-LEAD, MSOP, JEDEC MO-187, 3.0MM WIDE

# Physical Dimensions (Continued)



**Figure 10. 14-LEAD, SOIC, JEDEC MS-012, 0.150 INCH NARROW BODY**

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