

LP2995 DDR Termination Regulator

Check for Samples: [LP2995](#)

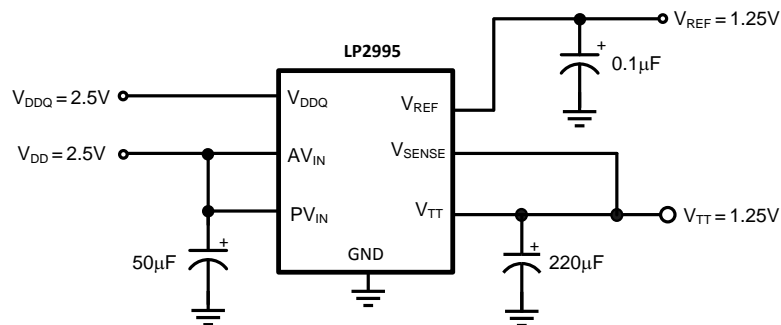
FEATURES

- Low Output Voltage Offset
- Works with +5v, +3.3v and 2.5v Rails
- Source and Sink Current
- Low External Component Count
- No External Resistors Required
- Linear Topology
- Available in SOIC-8, SO PowerPAD-8 or WQFN-16 Packages
- Low Cost and Easy to Use

APPLICATIONS

- DDR Termination Voltage
- SSTL-2
- SSTL-3

Typical Application Circuit



DESCRIPTION

The LP2995 linear regulator is designed to meet the JEDEC SSTL-2 and SSTL-3 specifications for termination of DDR-SDRAM. The device contains a high-speed operational amplifier to provide excellent response to load transients. The output stage prevents shoot through while delivering 1.5A continuous current and transient peaks up to 3A in the application as required for DDR-SDRAM termination. The LP2995 also incorporates a V_{SENSE} pin to provide superior load regulation and a V_{REF} output as a reference for the chipset and DDR DIMMS.

Patents Pending


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Connection Diagram

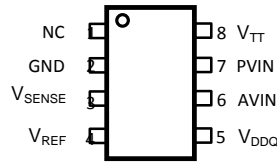


Figure 1. SOIC-8 (D0008A) Package Top View

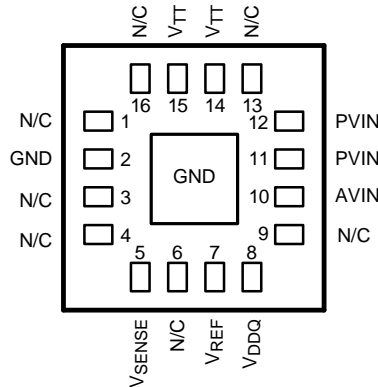


Figure 2. NHP-16 Package Top View

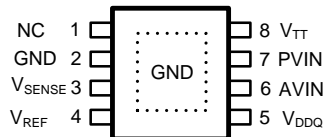


Figure 3. SO PowerPAD-8 (DDA0008A) Package Top View

PIN DESCRIPTIONS

| SOIC-8 Pin or SO PowerPAD-8 Pin | WQFN Pin | Name | Function |
|---------------------------------|------------------|--------|---|
| 1 | 1,3,4,6,9, 13,16 | NC | No internal connection. Can be used for vias. |
| 2 | 2 | GND | Ground. |
| 3 | 5 | VSENSE | Feedback pin for regulating VTT. |
| 4 | 7 | VREF | Buffered internal reference voltage of VDDQ/2. |
| 5 | 8 | VDDQ | Input for internal reference equal to VDDQ/2. |
| 6 | 10 | AVIN | Analog input pin. |
| 7 | 11, 12 | PVIN | Power input pin. |
| 8 | 14, 15 | VTT | Output voltage for connection to termination resistors. |
| | EP | EP | Exposed pad thermal connection. Connect to Ground. |



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

Absolute Maximum Ratings ⁽¹⁾⁽²⁾

| | |
|--|-----------------|
| AVIN to GND | -0.3V to +6V |
| PVIN to GND | -0.3V to AVIN |
| VDDQ ⁽³⁾ | -0.3V to +6V |
| Storage Temp. Range | -65°C to +150°C |
| Junction Temperature | 150°C |
| SO PowerPAD-8 Thermal Resistance (θ_{JA}) | 43°C/W |
| SOIC-8 Thermal Resistance (θ_{JA}) | 151°C/W |
| WQFN-16 Thermal Resistance (θ_{JA}) | 51°C/W |
| Lead Temperature (Soldering, 10 sec) | 260°C |
| ESD Rating ⁽⁴⁾ | 1kV |

- (1) Absolute maximum ratings indicate limits beyond which damage to the device may occur. Operating range indicates conditions for which the device is intended to be functional, but does not ensure specific performance limits. For ensured specifications and test conditions see Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
- (3) VDDQ voltage must be less than $2 \times (AVIN - 1)$ or 6V, whichever is smaller.
- (4) The human body model is a 100pF capacitor discharged through a 1.5k Ω resistor into each pin.

Operating Range

| | |
|-------------------------------------|---------------|
| Junction Temp. Range ⁽¹⁾ | 0°C to +125°C |
| AVIN to GND | 2.2V to 5.5V |
| PVIN to GND | 2.2V to AVIN |

- (1) At elevated temperatures, devices must be derated based on thermal resistance. The device in the SOIC-8 package must be derated at $\theta_{JA} = 151^\circ \text{C/W}$ junction to ambient with no heat sink. The device in the WQFN-16 must be derated at $\theta_{JA} = 51^\circ \text{C/W}$ junction to ambient.

Electrical Characteristics

Specifications with standard typeface are for $T_J = 25^\circ\text{C}$ and limits in **boldface type** apply over the full **Operating Temperature Range** ($T_J = 0^\circ\text{C}$ to $+125^\circ\text{C}$). Unless otherwise specified, AVIN = PVIN = 2.5V, VDDQ = 2.5V⁽¹⁾.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|------------------------|-----------------------------------|---|-------------------|-------------|-----------------|---------------|
| V_{REF} | V_{REF} Voltage | $I_{REF_OUT} = 0\text{mA}$ | 1.21 | 1.235 | 1.26 | V |
| $V_{OS_{VTT}}$ | V_{TT} Output Voltage Offset | $I_{OUT} = 0\text{A}$ ⁽²⁾ | -15 -20 | 0 | 15 20 | mV |
| $\Delta V_{TT}/V_{TT}$ | Load Regulation ⁽³⁾ | $I_{OUT} = 0$ to 1.5A $I_{OUT} = 0$ to -1.5A | | 0.5 -0.5 | | % |
| Z_{VREF} | V_{REF} Output Impedance | $I_{REF} = -5\mu\text{A}$ to $+5\mu\text{A}$ | | 5 | | k Ω |
| Z_{VDDQ} | VDDQ Input Impedance | | | 100 | | k Ω |
| I_q | Quiescent Current | $I_{OUT} = 0\text{A}$ ⁽⁴⁾ | | 250 | 400 | μA |

- (1) Limits are 100% production tested at 25°C. Limits over the operating temperature range are specified through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate TI's Average Outgoing Quality Level (AOQL).
- (2) V_{TT} offset is the voltage measurement defined as V_{TT} subtracted from V_{REF} .
- (3) Load regulation is tested by using a 10ms current pulse and measuring V_{TT} .
- (4) Quiescent current defined as the current flow into AVIN.

Typical Performance Characteristics

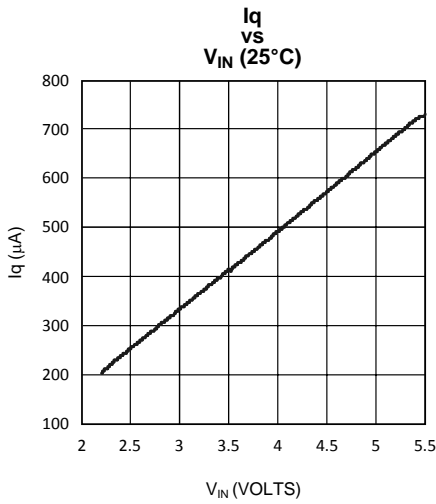


Figure 4.

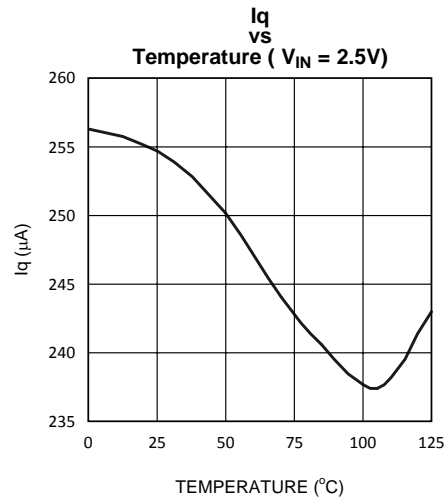


Figure 5.

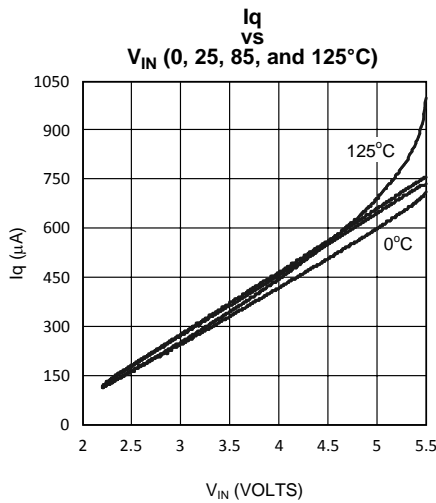


Figure 6.

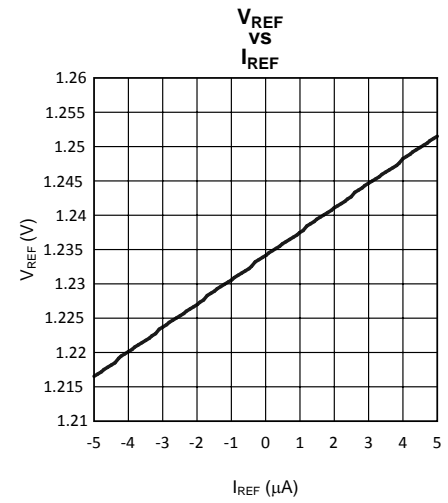


Figure 7.

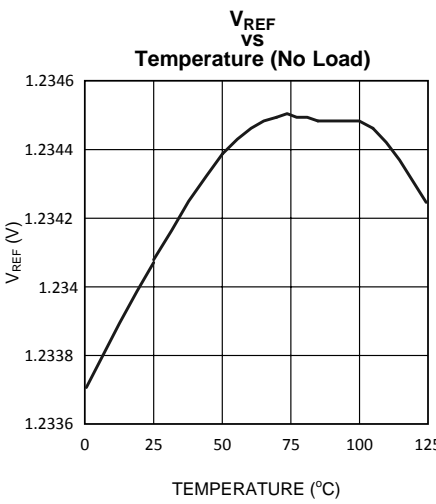


Figure 8.

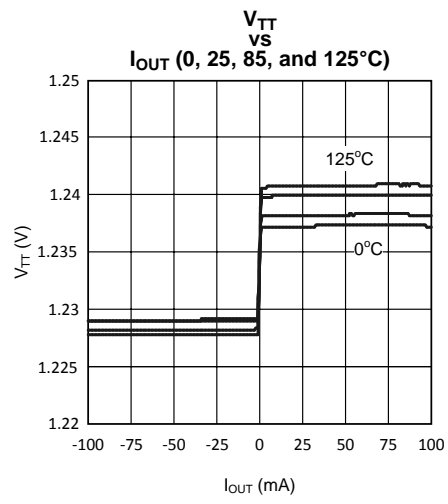


Figure 9.

Typical Performance Characteristics (continued)

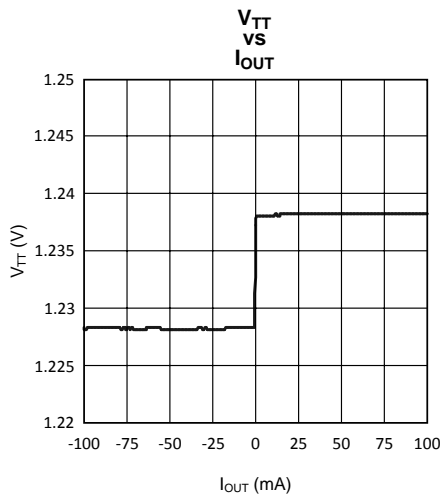


Figure 10.

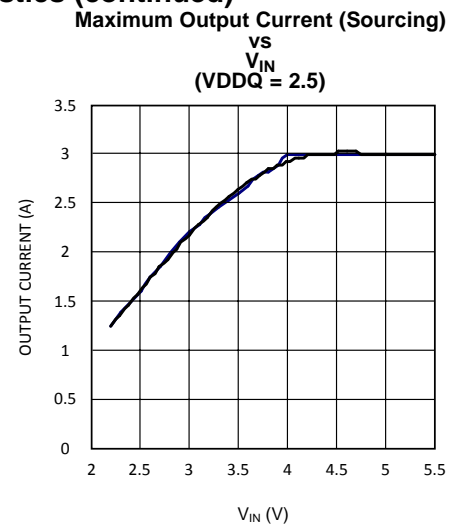


Figure 11.

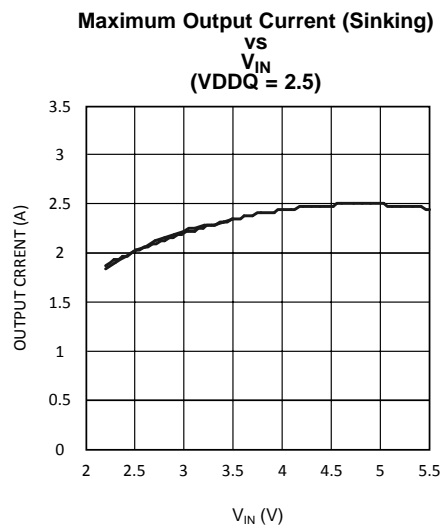
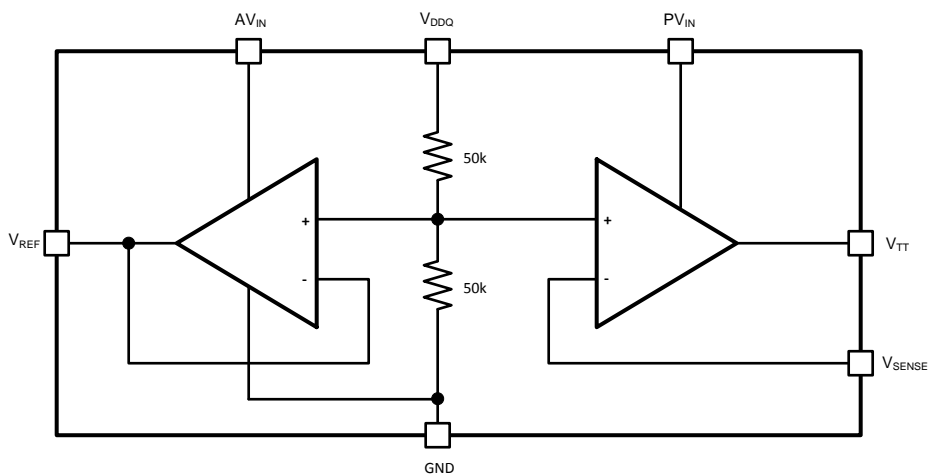


Figure 12.

Block Diagram



DETAILED DESCRIPTION

The LP2995 is a linear bus termination regulator designed to meet the JEDEC requirements of SSTL-2 and SSTL-3. The LP2995 is capable of sinking and sourcing current at the output V_{TT} , regulating the voltage to equal $V_{DDQ} / 2$. A buffered reference voltage that also tracks $V_{DDQ} / 2$ is generated on the V_{REF} pin for providing a global reference to the DDR-SDRAM and Northbridge Chipset. V_{TT} is designed to track the V_{REF} voltage with a tight tolerance over the entire current range while preventing shoot through on the output stage.

Series Stub Termination Logic (SSTL) was created to improve signal integrity of the data transmission across the memory bus. This termination scheme is essential to prevent data error from signal reflections while transmitting at high frequencies encountered with DDR RAM. The most common form of termination is Class II single parallel termination. This involves using one R_S series resistor from the chipset to the memory and one R_T termination resistor. This implementation can be seen below in Figure 13.

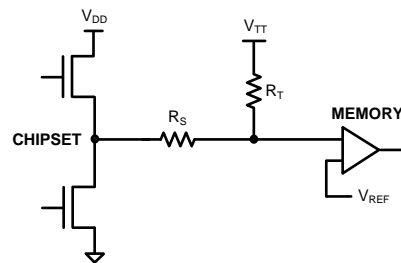


Figure 13.

Typical values for R_S and R_T are 25 Ohms although these can be changed to scale the current requirements from the LP2995. For determination of the current requirements of DDR-SDRAM termination please refer to the accompanying application notes.

Pin Descriptions

AVIN AND PVIN

AVIN and PVIN are the input supply pins for the LP2995. AVIN is used to supply all the internal control circuitry for the two op-amps and the output stage of V_{REF} . PVIN is used exclusively to provide the rail voltage for the output stage on the power operational amplifier used to create V_{TT} . For SSTL-2 applications AVIN and PVIN pins should be connected directly and tied to the 2.5V rail for optimal performance. This eliminates the need for bypassing the two supply pins separately.

VDDQ

VDDQ is the input that is used to create the internal reference voltage for regulating V_{TT} and V_{REF} . This voltage is generated by two internal 50k Ω resistors. This specifies that V_{TT} and V_{REF} will track $V_{DDQ} / 2$ precisely. The optimal implementation of VDDQ is as a remote sense for the reference input. This can be achieved by connecting VDDQ directly to the 2.5V rail at the DIMM. This ensures that the reference voltage tracks the DDR memory rails precisely without a large voltage drop from the power lines. For SSTL-2 applications VDDQ will be a 2.5V signal, which will create a 1.25V reference voltage on V_{REF} and a 1.25V termination voltage at V_{TT} . For SSTL-3 applications it may be desirable to have a different scaling factor for creating the internal reference voltage besides 0.5. For instance a typical value that is commonly used is to have the reference voltage equal $V_{DDQ} * 0.45$. This can be achieved by placing a resistor in series with the VDDQ pin to effectively change the resistor divider.

V_{SENSE}

The purpose of the sense pin is to provide improved remote load regulation. In most motherboard applications the termination resistors will connect to V_{TT} in a long plane. If the output voltage was regulated only at the output of the LP2995, then the long trace will cause a significant IR drop, resulting in a termination voltage lower at one end of the bus than the other. The V_{SENSE} pin can be used to improve this performance, by connecting it to the middle of the bus. This will provide a better distribution across the entire termination bus.

NOTE

If remote load regulation is not used, then the V_{SENSE} pin must still be connected to V_{TT} .

 V_{REF}

V_{REF} provides the buffered output of the internal reference voltage $V_{\text{DDQ}} / 2$. This output should be used to provide the reference voltage for the Northbridge chipset and memory. Since these inputs are typically an extremely high impedance, there should be little current drawn from V_{REF} . For improved performance, an output bypass capacitor can be used, located close to the pin, to help with noise. A ceramic capacitor in the range of 0.1 μF to 0.01 μF is recommended.

 V_{TT}

V_{TT} is the regulated output that is used to terminate the bus resistors. It is capable of sinking and sourcing current while regulating the output precisely to $V_{\text{DDQ}} / 2$. The LP2995 is designed to handle peak transient currents of up to $\pm 3\text{A}$ with a fast transient response. The maximum continuous current is a function of V_{IN} and can be viewed in the [Typical Performance Characteristics](#) section. If a transient is expected to last above the maximum continuous current rating for a significant amount of time then the output capacitor should be sized large enough to prevent an excessive voltage drop. Despite the fact that the LP2995 is designed to handle large transient output currents it is not capable of handling these for long durations, under all conditions. The reason for this is the standard packages are not able to thermally dissipate the heat as a result of the internal power loss. If large currents are required for longer durations, then care should be taken to ensure that the maximum junction temperature is not exceeded. Proper thermal derating should always be used (please refer to the [Thermal Dissipation](#) section).

Component Selection**INPUT CAPACITOR**

The LP2995 does not require a capacitor for input stability, but it is recommended for improved performance during large load transients to prevent the input rail from dropping. The input capacitor should be located as close as possible to the PVIN pin. Several recommendations exist dependent on the application required. A typical value recommended for AL electrolytic capacitors is 50 μF . Ceramic capacitors can also be used, a value in the range of 10 μF with X5R or better would be an ideal choice. The input capacitance can be reduced if the LP2995 is placed close to the bulk capacitance from the output of the 2.5V DC-DC converter.

OUTPUT CAPACITOR

The LP2995 has been designed to be insensitive of output capacitor size or ESR (Equivalent Series Resistance). This allows the flexibility to use any capacitor desired. The choice for output capacitor will be determined solely on the application and the requirements for load transient response of V_{TT} . As a general recommendation the output capacitor should be sized above 100 μF with a low ESR for SSTL applications with DDR-SDRAM. The value of ESR should be determined by the maximum current spikes expected and the extent at which the output voltage is allowed to droop. Several capacitor options are available on the market and a few of these are highlighted below:

- AL - It should be noted that many aluminum electrolytics only specify impedance at a frequency of 120 Hz, which indicates they have poor high frequency performance. Only aluminum electrolytics that have an impedance specified at a higher frequency (between 20 kHz and 100 kHz) should be used for the LP2995. To improve the ESR several AL electrolytics can be combined in parallel for an overall reduction. An important note to be aware of is the extent at which the ESR will change over temperature. Aluminum electrolytic capacitors can have their ESR rapidly increase at cold temperatures.
- Ceramic - Ceramic capacitors typically have a low capacitance, in the range of 10 to 100 μF range, but they have excellent AC performance for bypassing noise because of very low ESR (typically less than 10 m Ω). However, some dielectric types do not have good capacitance characteristics as a function of voltage and temperature. Because of the typically low value of capacitance it is recommended to use ceramic capacitors in parallel with another capacitor such as an aluminum electrolytic. A dielectric of X5R or better is recommended for all ceramic capacitors.
- Hybrid - Several hybrid capacitors such as OS-CON and SP are available from several manufacturers. These offer a large capacitance while maintaining a low ESR. These are the best solution when size and

performance are critical, although their cost is typically higher than any other capacitor.

Capacitor recommendations for different application circuits can be seen in the accompanying application notes with supporting evaluation boards.

Thermal Dissipation

Since the LP2995 is a linear regulator any current flow from V_{TT} will result in internal power dissipation generating heat. To prevent damaging the part from exceeding the maximum allowable junction temperature, care should be taken to derate the part dependent on the maximum expected ambient temperature and power dissipation. The maximum allowable internal temperature rise (T_{Rmax}) can be calculated given the maximum ambient temperature (T_{Amax}) of the application and the maximum allowable junction temperature (T_{Jmax}).

$$T_{Rmax} = T_{Jmax} - T_{Amax}$$

From this equation, the maximum power dissipation (P_{Dmax}) of the part can be calculated:

$$P_{Dmax} = T_{Rmax} / \theta_{JA}$$

The θ_{JA} of the LP2995 will be dependent on several variables: the package used; the thickness of copper; the number of vias and the airflow. For instance, the θ_{JA} of the SOIC-8 is 163°C/W with the package mounted to a standard 8x4 2-layer board with 1oz. copper, no airflow, and 0.5W dissipation at room temperature. This value can be reduced to 151.2°C/W by changing to a 3x4 board with 2 oz. copper that is the JEDEC standard. [Figure 14](#) shows how the θ_{JA} varies with airflow for the two boards mentioned.

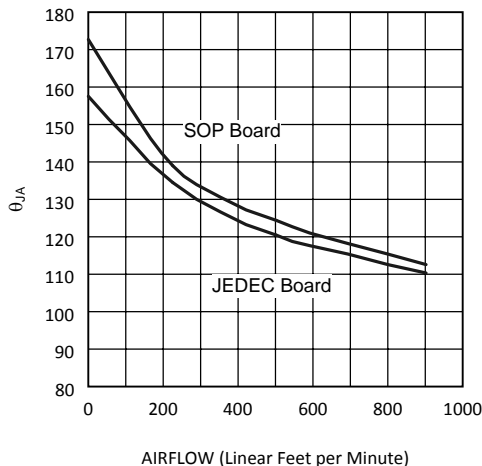


Figure 14. θ_{JA} vs Airflow (SOIC-8)

Layout is also extremely critical to maximize the output current with the WQFN package. By simply placing vias under the DAP the θ_{JA} can be lowered significantly. [Figure 15](#) shows the WQFN thermal data when placed on a 4-layer JEDEC board with copper thickness of 0.5/1/1/0.5 oz. The number of vias, with a pitch of 1.27 mm, has been increased to the maximum of 4 where a θ_{JA} of 50.41°C/W can be obtained. Via wall thickness for this calculation is 0.036 mm for 1oz. Copper.

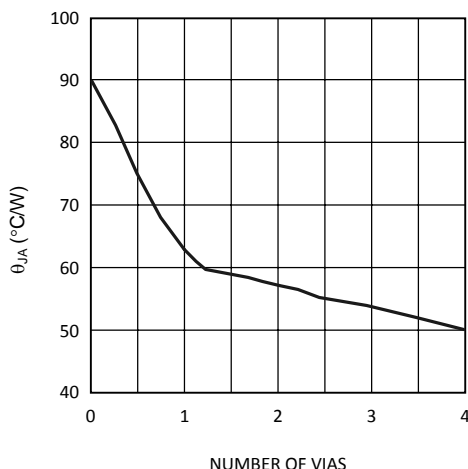


Figure 15. WQFN-16 θ_{JA} vs # of Vias (4 Layer JEDEC Board)

Additional improvements in lowering the θ_{JA} can also be achieved with a constant airflow across the package. Maintaining the same conditions as above and utilizing the 2x2 via array, [Figure 16](#) shows how the θ_{JA} varies with airflow.

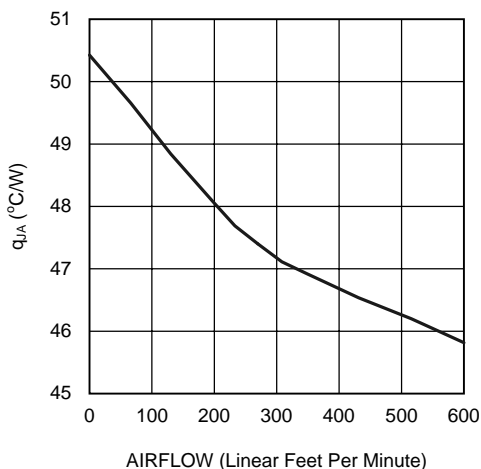


Figure 16. θ_{JA} vs Airflow Speed (JEDEC Board with 4 Vias)

Typical Application Circuits

The typical application circuit used for SSTL-2 termination schemes with DDR-SDRAM can be seen in [Figure 17](#).

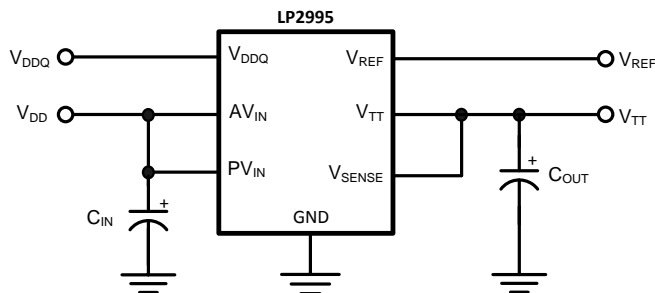


Figure 17. SSTL-2 Implementation

For SSTL-3 and other applications it may be desirable to change internal reference voltage scaling from $V_{DDQ} * 0.5$. An external resistor in series with the V_{DDQ} pin can be used to lower the reference voltage. Internally two 50 k Ω resistors set the output V_{TT} to be equal to $V_{DDQ} * 0.5$. The addition of a 11.1 k Ω external resistor will change the internal reference voltage causing the two outputs to track $V_{DDQ} * 0.45$. An implementation of this circuit can be seen in [Figure 18](#).

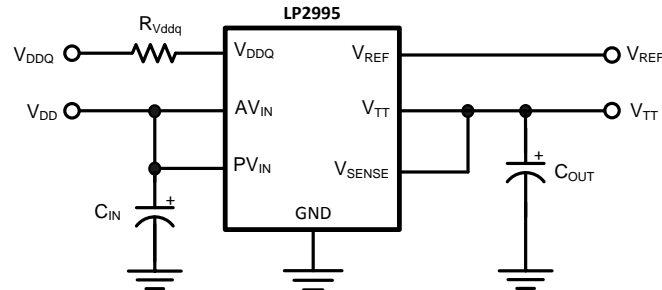


Figure 18. SSTL-3 Implementation

Another application that is sometimes required is to increase the V_{TT} output voltage from the scaling factor of $V_{DDQ} * 0.5$. This can be accomplished independently of V_{REF} by using a resistor divider network between V_{TT} , V_{SENSE} and Ground. An example of this circuit can be seen in [Figure 19](#).

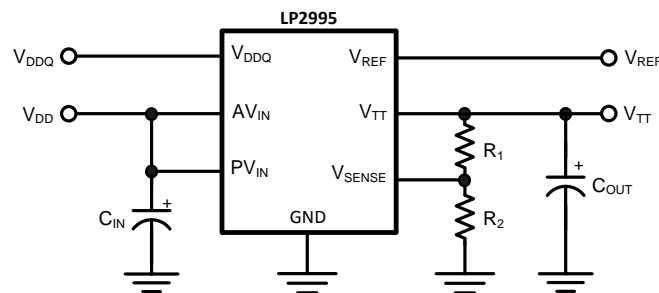


Figure 19.

PCB Layout Considerations

1. AVIN and PVIN should be tied together for optimal performance. A local bypass capacitor should be placed as close as possible to the PVIN pin.
2. GND should be connected to a ground plane with multiple vias for improved thermal performance.
3. V_{SENSE} should be connected to the V_{TT} termination bus at the point where regulation is required. For motherboard applications an ideal location would be at the center of the termination bus.
4. V_{DDQ} can be connected remotely to the V_{DDQ} rail input at either the DIMM or the Chipset. This provides the most accurate point for creating the reference voltage.
5. V_{REF} should be bypassed with a 0.01 μF or 0.1 μF ceramic capacitor for improved performance. This capacitor should be located as close as possible to the V_{REF} pin.

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Op Temp (°C) | Top-Side Markings (4) | Samples |
|------------------|---------------|--------------|--------------------|------|-------------|----------------------------|------------------|----------------------|--------------|--------------------------|-------------------------|
| LP2995LQ/NOPB | ACTIVE | WQFN | NHP | 16 | 1000 | Green (RoHS & no Sb/Br) | SN | Level-3-260C-168 HR | 0 to 125 | L00005B | Samples |
| LP2995M | ACTIVE | SOIC | D | 8 | 95 | TBD | CU SNPB | Level-1-235C-UNLIM | 0 to 125 | 2995M | Samples |
| LP2995M/NOPB | ACTIVE | SOIC | D | 8 | 95 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | 0 to 125 | 2995M | Samples |
| LP2995MR | ACTIVE | SO PowerPAD | DDA | 8 | 95 | TBD | CU SNPB | Level-3-260C-168 HR | 0 to 125 | LP2995 | Samples |
| LP2995MR/NOPB | ACTIVE | SO PowerPAD | DDA | 8 | 95 | Green (RoHS & no Sb/Br) | CU SN | Level-3-260C-168 HR | 0 to 125 | LP2995 | Samples |
| LP2995MRX | ACTIVE | SO PowerPAD | DDA | 8 | 2500 | TBD | CU SNPB | Level-3-260C-168 HR | 0 to 125 | LP2995 | Samples |
| LP2995MRX/NOPB | ACTIVE | SO PowerPAD | DDA | 8 | 2500 | Green (RoHS & no Sb/Br) | CU SN | Level-3-260C-168 HR | 0 to 125 | LP2995 | Samples |
| LP2995MX | ACTIVE | SOIC | D | 8 | 2500 | TBD | CU SNPB | Level-1-235C-UNLIM | 0 to 125 | 2995M | Samples |
| LP2995MX/NOPB | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | 0 to 125 | 2995M | Samples |

(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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

⁽⁴⁾ Only one of markings shown within the brackets will appear on the physical device.

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TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

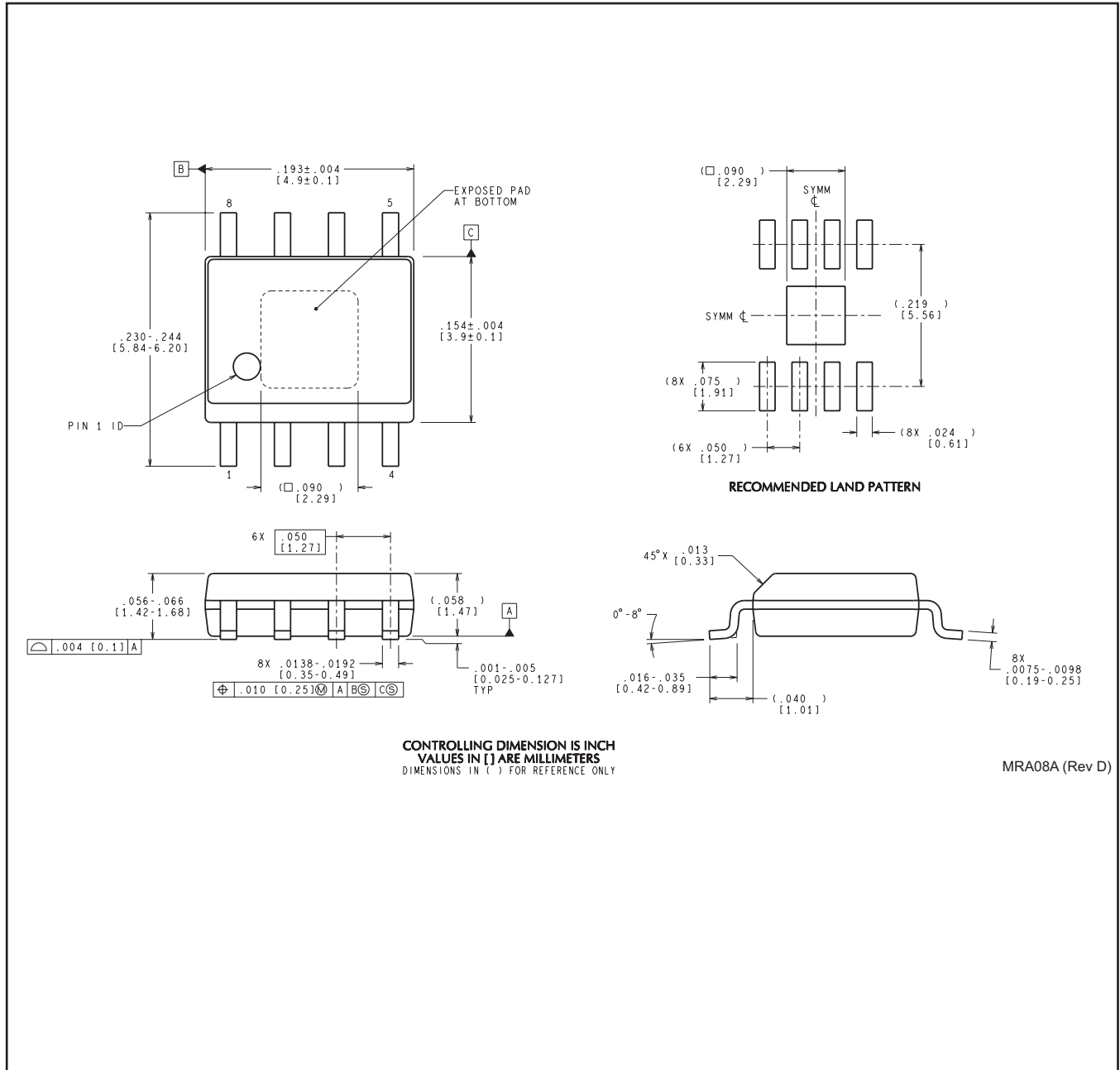
| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LP2995LQ/NOPB | WQFN | NHP | 16 | 1000 | 178.0 | 12.4 | 4.3 | 4.3 | 1.3 | 8.0 | 12.0 | Q1 |
| LP2995MRX | SO Power PAD | DDA | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LP2995MRX/NOPB | SO Power PAD | DDA | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LP2995MX | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LP2995MX/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LP2995LQ/NOPB | WQFN | NHP | 16 | 1000 | 203.0 | 190.0 | 41.0 |
| LP2995MRX | SO PowerPAD | DDA | 8 | 2500 | 358.0 | 343.0 | 63.0 |
| LP2995MRX/NOPB | SO PowerPAD | DDA | 8 | 2500 | 358.0 | 343.0 | 63.0 |
| LP2995MX | SOIC | D | 8 | 2500 | 349.0 | 337.0 | 45.0 |
| LP2995MX/NOPB | SOIC | D | 8 | 2500 | 349.0 | 337.0 | 45.0 |

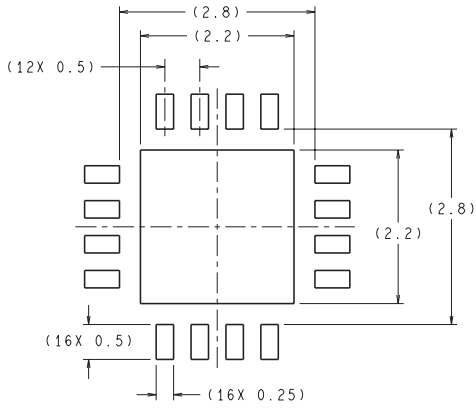
DDA0008A



CONTROLLING DIMENSION IS INCH
 VALUES IN [] ARE MILLIMETERS
 DIMENSIONS IN () FOR REFERENCE ONLY

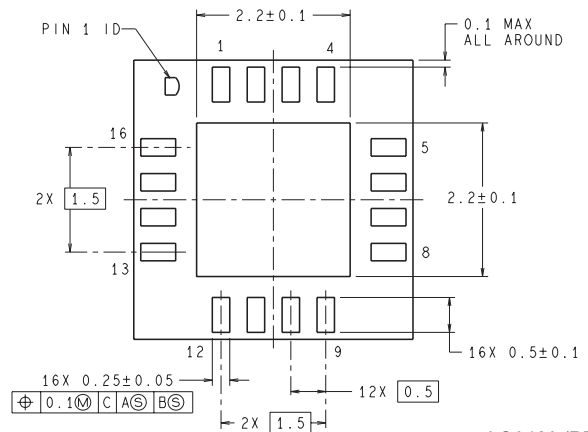
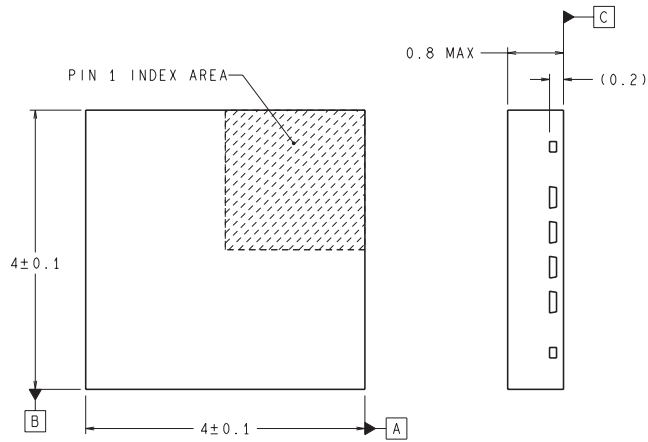
MRA08A (Rev D)

NHP0016A



RECOMMENDED LAND PATTERN
1:1 RATION WITH PKG SOLDER PADS

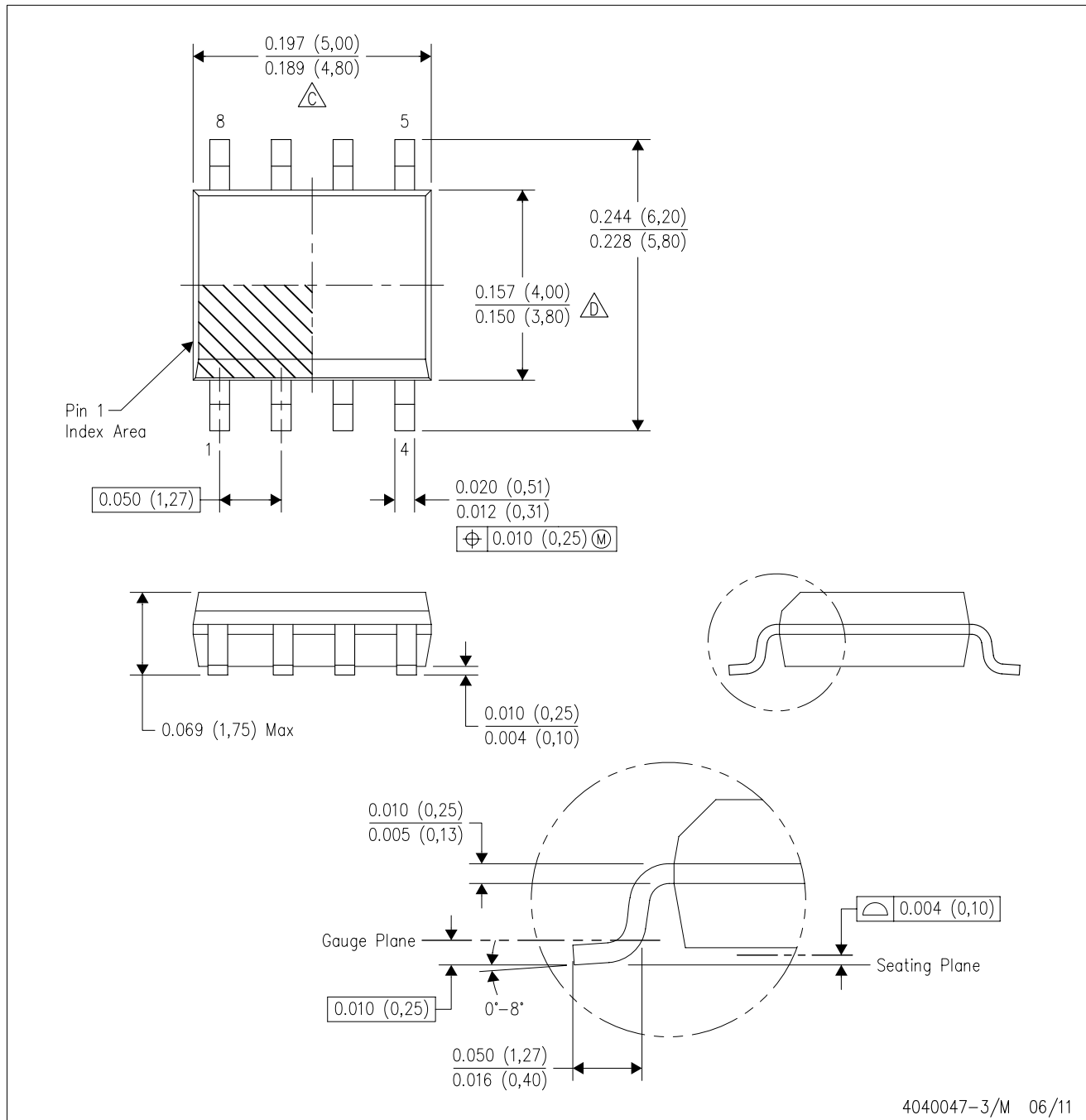
DIMENSIONS ARE IN MILLIMETERS



LQA16A (REV A)

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
 D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
 E. Reference JEDEC MS-012 variation AA.

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