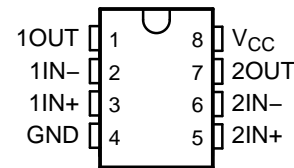


FEATURES

- Low Supply Current . . . 85 μ A Typ
- Low Offset Voltage . . . 2 mV Typ
- Low Input Bias Current . . . 2 nA Typ
- Input Common Mode to GND
- Wide Supply Voltage . . . 3 V < V_{CC} < 32 V
- Pin Compatible With LM358

D OR DGK PACKAGE
(TOP VIEW)



APPLICATIONS

- LCD Displays
- Portable Instrumentation
- Sensor/Metering Equipment
- Consumer Electronics (MP3 Players, Toys)
- Power Supplies

DESCRIPTION/ORDERING INFORMATION

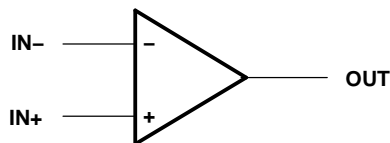
The LP358 and LP2904 are dual low-power operational amplifiers especially suited for battery-operated applications. Good input specifications and wide supply-voltage range still are achieved, despite the ultra-low supply current. Single-supply operation is achieved with an input common-mode range that includes GND.

The LP358 and LP2904 are ideal in applications where wide supply voltage and low power are more important than speed and bandwidth. These applications include portable instrumentation, LCD displays, consumer electronics (MP3 players, toys, etc.), and power supplies.

ORDERING INFORMATION

| T_A | PACKAGE ⁽¹⁾ | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---------------|------------------------|--------------|-----------------------|------------------|
| 0°C to 70°C | SOIC – D | Tube of 75 | LP358D | LP358 |
| | | Reel of 2500 | LP358DR | |
| | VSSOP – DGK | Tube of 100 | LP358DGK | PREVIEW |
| | | Reel of 250 | LP358DGKT | |
| Reel of 2500 | LP358DGKR | | | |
| –40°C to 85°C | SOIC – D | Tube of 75 | LP2904D | PREVIEW |
| | | Reel of 2500 | LP2904DR | |
| | VSSOP – DGK | Tube of 100 | LP2904DGK | PREVIEW |
| | | Reel of 250 | LP2904DGKT | |
| | | Reel of 2500 | LP2904DGKR | |

SYMBOL (EACH AMPLIFIER)

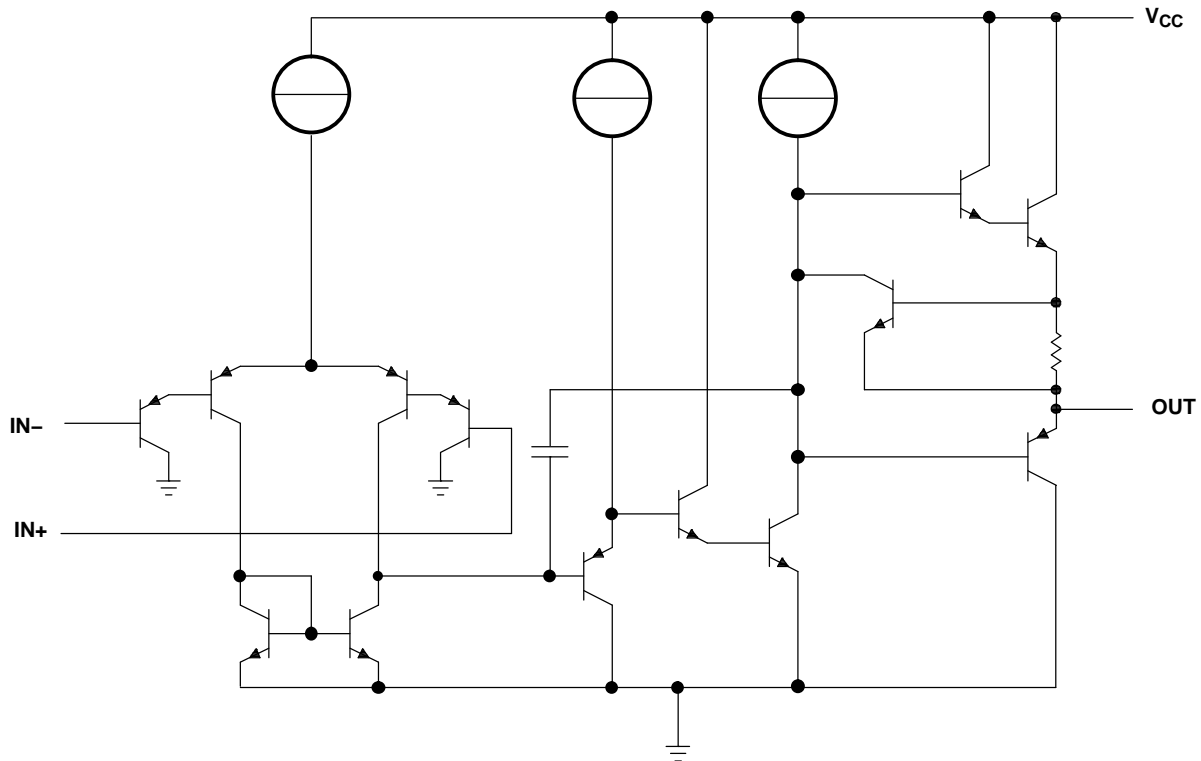


- (1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.



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SCHEMATIC (EACH AMPLIFIER)



Absolute Maximum Ratings⁽¹⁾

over operating free-air temperature range (unless otherwise noted)

| | | MIN | MAX | UNIT |
|---------------|--|------|-----------|------|
| V_{CC} | Supply voltage range ⁽²⁾ | | ±16 or 32 | V |
| V_{ID} | Differential input voltage ⁽³⁾ | | ±32 | V |
| V_I | Input voltage (either input) | -0.3 | 32 | V |
| | Duration of output short circuit (one amplifier) to ground at (or below) $T_A = 25^\circ\text{C}$, $V_{CC} \leq 15\text{ V}$ ⁽⁴⁾ | | Unlimited | |
| θ_{JA} | Package thermal impedance ⁽⁵⁾⁽⁶⁾ | | 97 | °C/W |
| | | | 172 | |
| T_J | Operating virtual junction temperature | | 150 | °C |
| T_{stg} | Storage temperature range | -65 | 150 | °C |

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values (except differential voltages and V_{CC} specified for the measurement of I_{OS}) are with respect to the network GND.
- (3) Differential voltages are at IN+, with respect to IN-.
- (4) Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.
- (5) Maximum power dissipation is a function of $T_J(\text{max})$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
- (6) The package thermal impedance is calculated in accordance with JESD 51-7.

ESD Protection

| TEST CONDITIONS | TYP | UNIT |
|------------------|-----|------|
| Human-Body Model | ±2 | kV |

Electrical Characteristics

$T_A = 25^\circ\text{C}$, $V_{CC} = 5\text{ V}$, $V_{IC} = V_{CC}/2$, $R_L = 100\text{ k}\Omega$ to GND (unless otherwise noted)

| PARAMETER | TEST CONDITIONS ⁽¹⁾ | T_A ⁽²⁾ | LP358 | | LP2904 | | UNIT |
|--|--|----------------------|----------------|--------------------|----------------|------------------------------|---------------|
| | | | MIN | TYP ⁽³⁾ | MAX | MIN | |
| V_{IO} Input offset voltage | | 25°C | 2 | 4 | 2 | 4 | mV |
| | | Full range | | 9 | | 10 | |
| I_{IB} Input bias current | | 25°C | 2 | 10 | 2 | 20 | nA |
| | | Full range | | 20 | | 40 | |
| I_{IO} Input offset current | | 25°C | 0.2 | 2 | 0.5 | 4 | nA |
| | | Full range | | 4 | | 8 | |
| A_V Large-signal voltage gain | $R_L = 10\text{ k}\Omega$ to GND, $V_{CC} = 30\text{ V}$ | 25°C | 50 | 100 | 40 | 70 | V/mV |
| | | Full range | 40 | | 30 | | |
| CMRR Common-mode rejection ratio | $V_{CC} = 30\text{ V}$, $V_{IC} = 0\text{ V}$ to $V_{CC} - 1.5\text{ V}$ | 25°C | 80 | 90 | 80 | 90 | dB |
| | | Full range | 75 | | 75 | | |
| k_{VSR} Power-supply rejection ratio | $V_{CC} = 5\text{ V}$ to 30 V | 25°C | 80 | 90 | 80 | 90 | V |
| | | Full range | 75 | | 75 | | |
| I_{CC} Supply current | $R_L = \infty$ | 25°C | 85 | 150 | 85 | 150 | μA |
| | | Full range | | 250 | | 275 | |
| V_{OH} Output voltage swing (high) | $I_L = 0.35\text{ mA}$ to GND, $V_{IC} = 0\text{ V}$ | 25°C | 3.4 | 3.6 | 3.4 | 3.6 | V |
| | | Full range | $V_{CC} - 1.9$ | | $V_{CC} - 1.9$ | | |
| V_{OL} Output voltage swing (low) | $I_L = 0.35\text{ mA}$ from V_{CC} , $V_{IC} = 0\text{ V}$ | 25°C | 0.82 | 0.7 | 0.82 | 0.7 | V |
| | | Full range | 1 | | 1 | | |
| I_O Output source current | $V_O = 3\text{ V}$, $V_{ID} = 1\text{ V}$ | 25°C | 7 | 10 | 7 | 10 | mA |
| | | Full range | 4 | | 4 | | |
| I_O Output sink current | $V_O = 1.5\text{ V}$, $V_{ID} = -1\text{ V}$ | 25°C | 4 | 5 | 4 | 5 | mA |
| | | Full range | 3 | | 3 | | |
| | $V_O = 1.5\text{ V}$, $V_{ID} = -1\text{ V}$, $V_{IC} = 0\text{ V}$ | 25°C | 2 | 4 | 2 | 4 | |
| | | Full range | 1 | | 1 | | |
| $I_{OS,GND}$ Output short to GND | $V_{ID} = 1\text{ V}$ | 25°C | 20 | 35 | 20 | 35 | mA |
| | | Full range | | 40 | | 40 | |
| $I_{OS,VCC}$ Output short to V_{CC} | $V_{ID} = -1\text{ V}$ | 25°C | 15 | 30 | 15 | 30 | mA |
| | | Full range | | 45 | | 45 | |
| αV_{IO} Input offset voltage drift | | 25°C | 10 | | 10 | $\mu\text{V}/^\circ\text{C}$ | |
| αI_{IO} Input offset current drift | | 25°C | 10 | | 10 | $\text{pA}/^\circ\text{C}$ | |

(1) For full-range temperature limits: $V_{CC} = 3\text{ V}$ to 32 V , $V_{ICR} = 0\text{ V}$ to $V_{CC} - 1.5\text{ V}$ (unless otherwise noted)

(2) Full range is 0°C to 70°C for LP358 and -40°C to 85°C for LP2904.

(3) All typical values are at $T_A = 25^\circ\text{C}$.

Operating Conditions

$V_{CC} = \pm 15\text{ V}$, $T_A = 25^\circ\text{C}$

| PARAMETER | | TYP | UNIT |
|-----------|------------------------|-----|------|
| GBW | Gain bandwidth product | 100 | kHz |
| SR | Slew rate | 50 | V/ms |

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| LP2904D | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LP2904DE4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LP2904DG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LP2904DR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LP2904DRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LP358D | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LP358DE4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LP358DG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LP358DR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LP358DRE4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LP358DRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |

⁽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.

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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 |
|----------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LP2904DR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| LP358DR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS

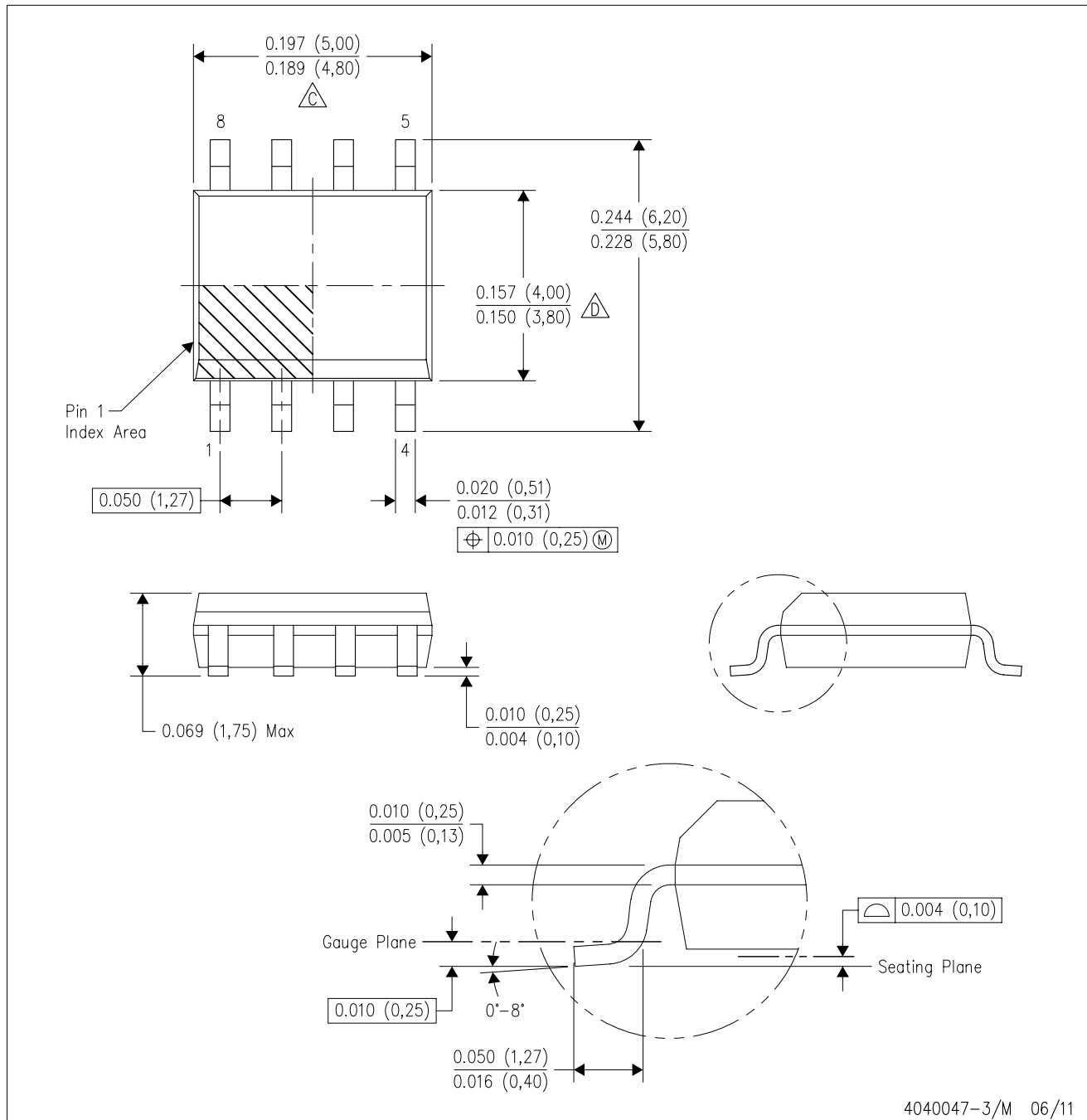


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|----------|--------------|-----------------|------|------|-------------|------------|-------------|
| LP2904DR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| LP358DR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |

D (R-PDSO-G8)

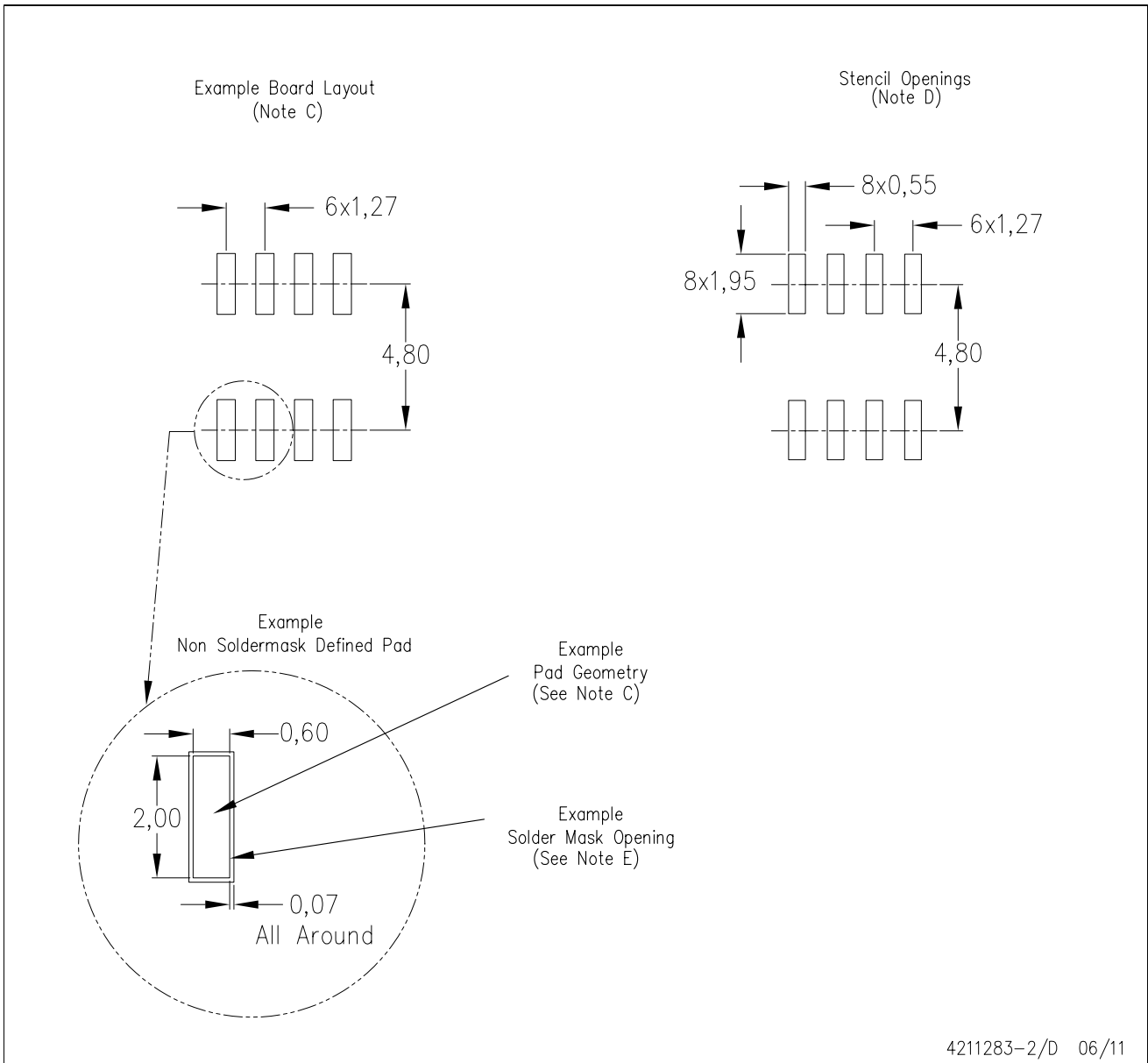
PLASTIC SMALL OUTLINE



- 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.

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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