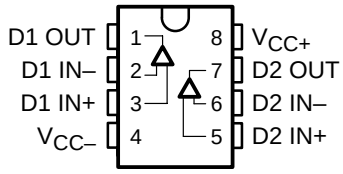
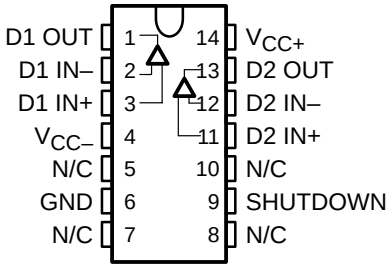
- **Remote Terminal ADSL Line Driver**
  - **Ideal for Both Full Rate ADSL and G.Lite**
  - **Compatible With 1:2 Transformer Ratio**
- **Wide Supply Voltage Range +5 V to +14 V**
  - **Ideal for Single Supply +12-V Operation**
- **Low 2.1 pA/$\sqrt{\text{Hz}}$ Noninverting Current Noise**
  - **Reduces Noise Feedback Through Hybrid Into Downstream Channel**
- **Wide Output Swing**
  - **18.4 Vpp Differential Output Voltage, $R_L$ = 50 Ω, 12-V Single Supply**
- **High Output Current**
  - **275 mA (typ)**
- **High Speed**
  - **100 MHz (–3 dB, G=1, 12-V Single Supply)**
  - **600 V/μs Slew Rate (G = 4, 12-V Single Supply)**
- **Low Distortion, Single-Ended, G = 4**
  - **–72 dBc (250 kHz, 2 Vpp, 25 Ω load)**
  - **–78 dBc (250 kHz, 2 Vpp, 100 Ω load)**
- **Low Power Shutdown (THS6093)**
  - **300 μA Total Standby Current**
- **Thermal Shutdown and Short Circuit Protection**
- **Standard SOIC, SOIC PowerPAD™, and TSSOP PowerPAD™ Package**
- **Evaluation Module Available**

**THS6092**
**SOIC (D) AND**
**SOIC PowerPAD™ (DDA) PACKAGE**
**(TOP VIEW)**

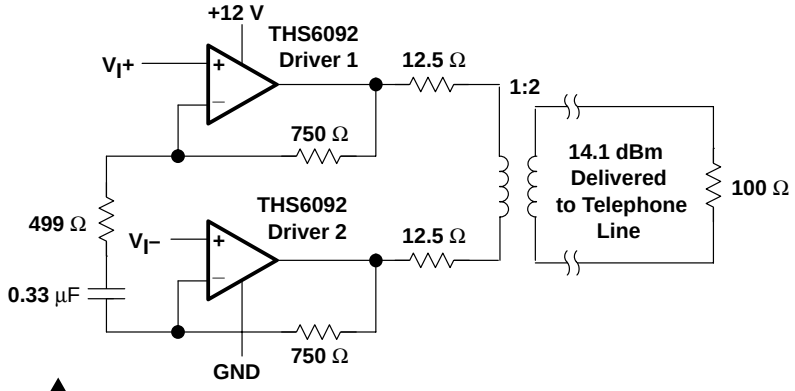



**THS6093**
**SOIC (D) AND**
**TSSOP PowerPAD™ (PWP) PACKAGE**
**(TOP VIEW)**




## description

The THS6092/3 is a high-speed line driver ideal for driving signals from the remote terminal to the central office in asymmetrical digital subscriber line (ADSL) applications. It can operate from a single +12-V supply voltage while drawing only 7.3 mA of supply current per channel. It offers low –72 dBc total harmonic distortion driving a 25-Ω load (2 Vpp). The THS6092/3 offers a high 18.4-Vpp differential output swing across a 50-Ω load from a single +12-V supply. The THS6093 features a low-power shutdown mode, consuming only 300 μA quiescent current per channel. The THS6092/3 is packaged in a standard SOIC, SOIC PowerPAD™, and TSSOP PowerPAD™ package.




**RELATED PRODUCTS**

| DEVICE | DESCRIPTION |
|---|---|
| THS6042/3 | 350-mA, ±12 ADSL CPE line driver |
| THS6052/3 | 175-mA, ±12 V ADSL CPE line driver |
| OPA2677 | 380-mA, +12 V ADSL CPE line driver |
| THS6062 | Low noise ADSL receiver |

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PowerPAD is a trademark of Texas Instruments.

**AVAILABLE OPTIONS**

| $T_A$ | PACKAGED DEVICE | | | | EVALUATION MODULES |
|---|---|---|---|---|---|
| | SOIC-8† (D) | SOIC-8† PowerPAD (DDA) | SOIC-14† (D) | TSSOP-14† PowerPAD (PWP) | |
| 0°C to 70°C | THS6092CD | THS6092CDDA | THS6093CD | THS6093CPWP | THS6092EVM THS6093EVM |
| –40°C to 85°C | THS6092ID | THS6092IDDA | THS6093ID | THS6093IPWP | — |

† All packages are available taped and reeled. Add an R-suffix to the device type (i.e., THS6092IDR).

## absolute maximum ratings over operating free-air temperature (unless otherwise noted)†

Supply voltage, $V_{CC+}$ to $V_{CC-}$ . . . . . 14.7 V
Input voltage . . . . . ± $V_{CC}$
Output current (see Note 1) . . . . . 350 mA
Differential input voltage . . . . . ± 3 V
Maximum junction temperature . . . . . 150°C
Total power dissipation at (or below) 25°C free-air temperature . . . . . See Dissipation Ratings Table
Operating free-air temperature, $T_A$: Commercial . . . . . 0°C to 70°C
Industrial . . . . . –40°C to 85°C
Storage temperature, $T_{stg}$ : Commercial . . . . . –65°C to 125°C
Industrial . . . . . –65°C to 125°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 300°C

† 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.

NOTE 1: The THS6092 and THS6093 may incorporate a PowerPAD™ on the underside of the chip. This acts as a heatsink and must be connected to a thermally dissipating plane for proper power dissipation. Failure to do so may result in exceeding the maximum junction temperature which could permanently damage the device. See TI Technical Brief SLMA002 for more information about utilizing the PowerPAD™ thermally enhanced package.

**DISSIPATION RATING TABLE**

| PACKAGE | $\theta_{JA}$ | $\theta_{JC}$ | $T_A$ = 25°C§ POWER RATING | $T_A$ = 70°C§ POWER RATING | $T_A$ = 85°C§ POWER RATING |
|---|---|---|---|---|---|
| D-8 | 95°C/W‡ | 38.3°C/W‡ | 1.1 W | 0.63 W | 0.47 W |
| DDA | 45.8°C/W | 9.2°C/W | 2.3 W | 1.31 W | 0.98 W |
| D-14 | 66.6°C/W‡ | 26.9°C/W‡ | 1.6 W | 0.90 W | 0.68 W |
| PWP | 37.5°C/W | 1.4°C/W | 2.8 W | 1.60 W | 1.20 W |

‡ This data was taken using the JEDEC proposed high-K test PCB. For the JEDEC low-K test PCB, the $\Theta_{JA}$ is168°C/W for the D–8 package and 122.3°C/W for the D–14 package.

§ Power rating is determined with a junction temperature of 130°C. This is the point where distortion starts to substantially increase. Thermal management of the final PCB should strive to keep the junction temperature at or below 125°C for best performance.

## recommended operating conditions

| | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|
| Supply voltage, $V_{CC+}$ to $V_{CC-}$ | Dual supply | ±2.5 | | ±7 | V |
| | Single supply | +5 | | +14 | |
| Operating free-air temperature, $T_A$ | C-suffix | 0 | | 70 | °C |
| | I-suffix | –40 | | 85 | |

## electrical characteristics over recommended operating free-air temperature range, $T_A$ = 25°C, $V_{CC+}$ = 12 V, $V_{CC-}$ = GND, $R_{FEEDBACK}$ = 750 Ω, $R_L$ = 25 Ω (unless otherwise noted)

### dynamic performance

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| BW | Small-signal bandwidth (–3 dB) G=1 | $V_{CC}$ = 12 V | | 100 | | MHz |
| | | $V_{CC}$ = 5 V | | 90 | | |
| SR | Slew rate (see Note 2) | $V_{CC}$ = 12 V | | 600 | | V/μs |
| | | $V_{CC}$ = 5 V | | 400 | | |

NOTE 2: Slew rate is defined from the 25% to the 75% output levels.

### noise/distortion performance

| PARAMETER | | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| THD | Total harmonic distortion (single-ended configuration) | | Gain = 4, $R_L$ = 25 Ω, $V_{CC}$ = 5 V, f = 250 kHz | $V_{O(pp)}$ = 2 V | | –70 | | dBc |
| | | | Gain = 4, $R_L$ = 25 Ω, $V_{CC}$ = 12 V, f = 250 kHz | $V_{O(pp)}$= 2 V | | –72 | | |
| | | | | $V_{O(pp)}$= 7 V | | –68 | | |
| $V_n$ | Input voltage noise | | $V_{CC}$ = 12 V, 5 V, f = 10 kHz | | | 2.1 | | nV/√Hz |
| $I_n$ | Input current noise | +Input | $V_{CC}$ = 12 V, 5 V, f = 10 kHz | | | 2.1 | | pA/√Hz |
| | | –Input | | | | 10.9 | | |
| $X_T$ | Crosstalk | | f = 250 kHz, G = 4, $V_O$ = 2 Vpp, $R_L$= 25 Ω | $V_{CC}$ = 5 V | | –65 | | dBc |
| | | | | $V_{CC}$ = 12 V | | –63 | | |

### dc performance

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $V_{OS}$ | Input offset voltage | $V_{CC}$ = 12 V, 5 V | $T_A$ = 25°C | | 6 | 16 | mV |
| | | | $T_A$ = full range | | | 21 | |
| | Differential offset voltage | | $T_A$ = 25°C | | 1 | 6 | |
| | | | $T_A$ = full range | | | 8 | |
| | Offset drift | | $T_A$ = full range | | 20 | | μV/°C |
| $I_{IB}$ | – Input bias current | $V_{CC}$ = 12 V, 5 V | $T_A$ = 25°C | | 3 | 10 | μA |
| | | | $T_A$ = full range | | | 12 | |
| | + Input bias current | | $T_A$ = 25°C | | 1 | 6 | |
| | | | $T_A$ = full range | | | 7 | |
| | Differential input bias current | | $T_A$ = 25°C | | 3 | 10 | |
| | | | $T_A$ = full range | | | 12 | |
| $Z_{OL}$ | Open loop transimpedance | $R_L$ = 1 kΩ | $V_{CC}$ = 12 V, 5 V | | 0.9 | | MΩ |

## electrical characteristics over recommended operating free-air temperature range, $T_A$ = 25°C, $V_{CC+}$ = 12 V, $V_{CC-}$ = GND, $R_{FEEDBACK}$ = 750 Ω, $R_L$ = 25 Ω (unless otherwise noted) (continued)

### input characteristics

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $V_{ICR}$ | Input common-mode voltage range | $V_{CC}$ = 5 V | $T_A$ = 25°C | 1.5 to 3.5 | 1.1 to 3.9 | | V |
| | | | $T_A$ = full range | 1.6 to 3.4 | | | |
| | | $V_{CC}$ = 12 V | $T_A$ = 25°C | 2.3 to 9.7 | 1.8 to 10.2 | | |
| | | | $T_A$ = full range | 2.4 to 9.6 | | | |
| CMRR | Common-mode rejection ratio | $V_{CC}$ = 5 V | $T_A$ = 25°C | 56 | 63 | | dB |
| | | | $T_A$ = full range | 54 | | | |
| | | $V_{CC}$ = 12 V | $T_A$ = 25°C | 50 | 56 | | |
| | | | $T_A$ = full range | 48 | | | |
| $R_I$ | Input resistance | + Input | | | 1 | | MΩ |
| | | –Input | | | 15 | | Ω |
| $C_I$ | Input capacitance | | | | 2 | | pF |

### output characteristics

| PARAMETER | | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_O$ | Output voltage swing | Single ended 100 mV overdrive | $R_L$ = 25 Ω | $V_{CC}$ = 5 V | 1.4 to 3.6 | 1.1 to 3.9 | | V |
| | | | | $V_{CC}$ = 12 V | 1.9 to 10.1 | 1.4 to 10.6 | | |
| | | | $R_L$ = 100 Ω | $V_{CC}$ = 5 V | 1.3 to 3.7 | 1.05 to 3.95 | | |
| | | | | $V_{CC}$ = 12 V | 1.5 to 10.5 | 1.1 to 10.9 | | |
| $I_O$ | Output current | | $R_L$ = 3.6 Ω, | $V_{CC}$ = 5 V | | 240 | | mA |
| | | | $R_L$ = 10 Ω, | $V_{CC}$ = 12 V | 240 | 275 | | |
| $I_{SC}$ | Short-circuit current | | $R_L$ = 0 Ω, | $V_{CC}$ = 12 V | | 325 | | mA |
| | Output resistance | | Open loop | | | 15 | | Ω |

### power supply

| PARAMETER | | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{CC}$ | Operating range | Dual supply | | | ±2.25 | | ±7 | V |
| | | Single supply | | | 4.5 | | 14 | |
| $I_{CC}$ | Quiescent current (each driver) | | $V_{CC}$ = 5 V | $T_A$ = 25°C | | 6.7 | 8.8 | mA |
| | | | | $T_A$ = full range | | | 10 | |
| | | | $V_{CC}$ = 12 V | $T_A$ = 25°C | | 7.3 | 9.5 | mA |
| | | | | $T_A$ = full range | | | 10.5 | |
| PSRR | Power supply rejection ratio | | $V_{CC}$ = 5 V | $T_A$ = 25°C | -54 | –58 | | dB |
| | | | | $T_A$ = full range | -46 | – | | |
| | | | $V_{CC}$ = 12 V | $T_A$ = 25°C | -58 | –70 | | |
| | | | | $T_A$ = full range | -50 | | | |

**electrical characteristics over recommended operating free-air temperature range, $T_A$ = 25°C, $V_{CC+}$ = 12 V, $V_{CC-}$ = GND, $R_{FEEDBACK}$ = 750 Ω, $R_L$ = 25 Ω (unless otherwise noted) (continued)**

**shutdown characteristics (THS6093 only)**

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{IL(SHDN)}$ | Shutdown pin voltage for power up | $V_{CC}$ = 12 V, GND = 6 V (GND Pin as Reference) | | | 0.8 | V |
| $V_{IH(SHDN)}$ | Shutdown pin voltage for power down | $V_{CC}$ = 12 V, GND = 6 V (GND Pin as Reference) | 2 | | | V |
| $I_{CC(SHDN)}$ | Total quiescent current when in shutdown state | $V_{SHDN}$ = 8 V, $V_{GND}$ = 6 V, $V_{CC}$ = 12 V | | 0.3 | 0.7 | mA |
| $t_{DIS}$ | Disable time (see Note 3) | $V_{CC}$ = 12 V | | 0.2 | | µs |
| $t_{EN}$ | Enable time (see Note 3) | $V_{CC}$ = 12 V | | 0.5 | | µs |
| $I_{IL(SHDN)}$ | Shutdown pin input bias current for power up | $V_{SHDN}$ = 6 V, $V_{GND}$ = 6 V, $V_{CC}$ = 12 V | | 40 | 100 | µA |
| $I_{IH(SHDN)}$ | Shutdown pin input bias current for power down | $V_{SHDN}$ = 9.3 V, $V_{GND}$ = 6 V, $V_{CC}$ = 12 V | | 50 | 100 | µA |

NOTE 3: Disable/enable time is defined as the time from when the shutdown signal is applied to the SHDN pin to when the supply current has reached half of its final value.

## APPLICATION INFORMATION

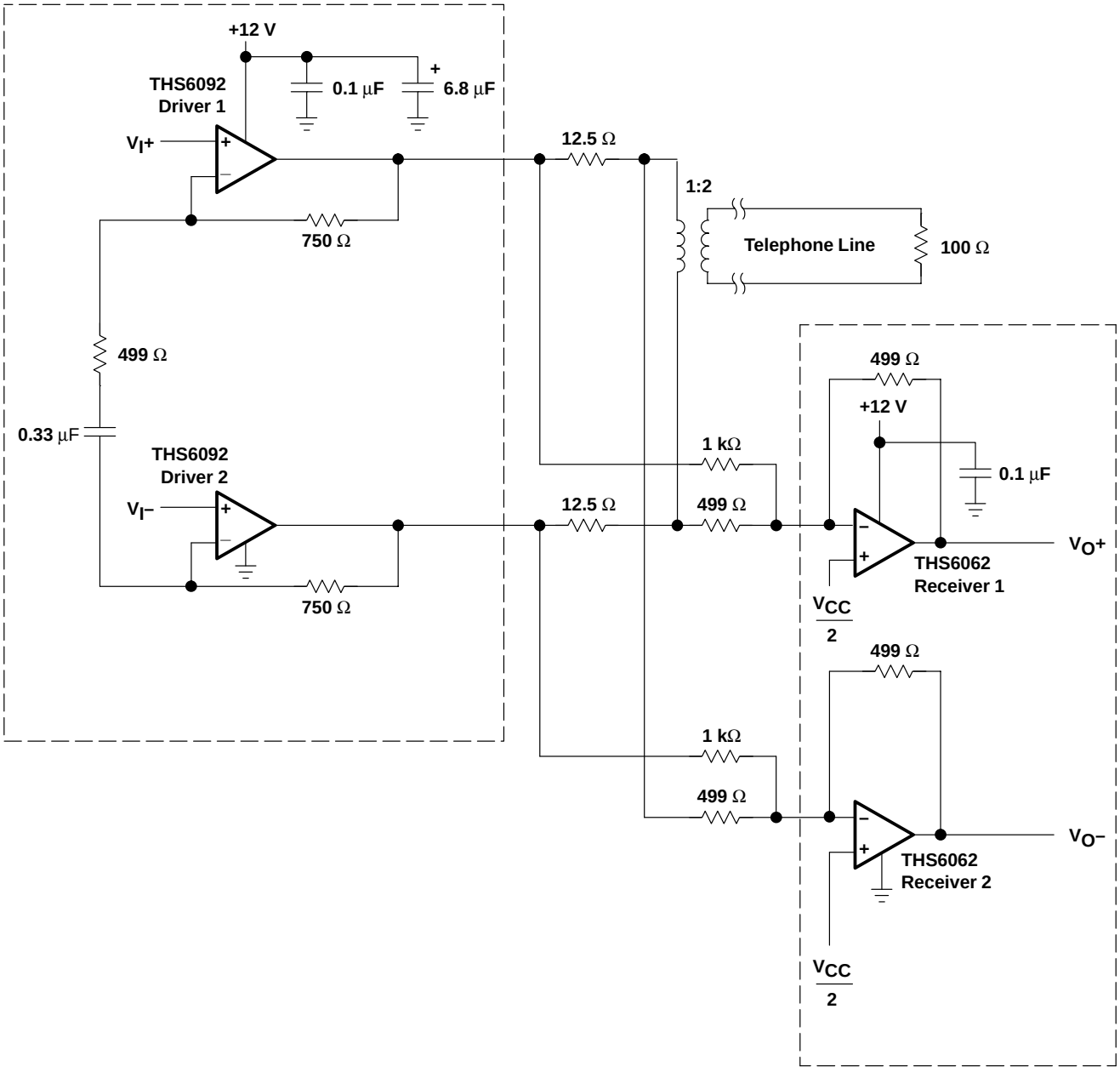
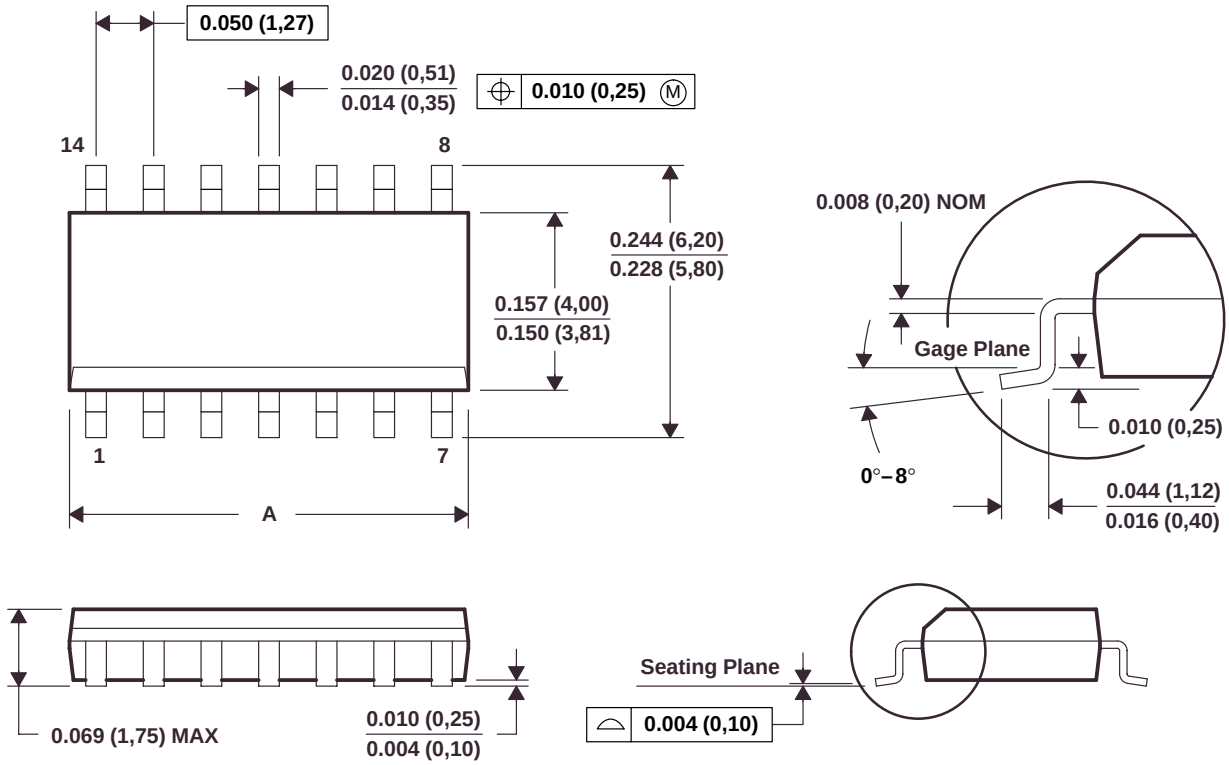



**Figure 1. THS6092 ADSL Application With 1:2 Transformer Ratio**

## MECHANICAL DATA

**D (R-PDSO-G**)** **PLASTIC SMALL-OUTLINE PACKAGE**

**14 PINS SHOWN**



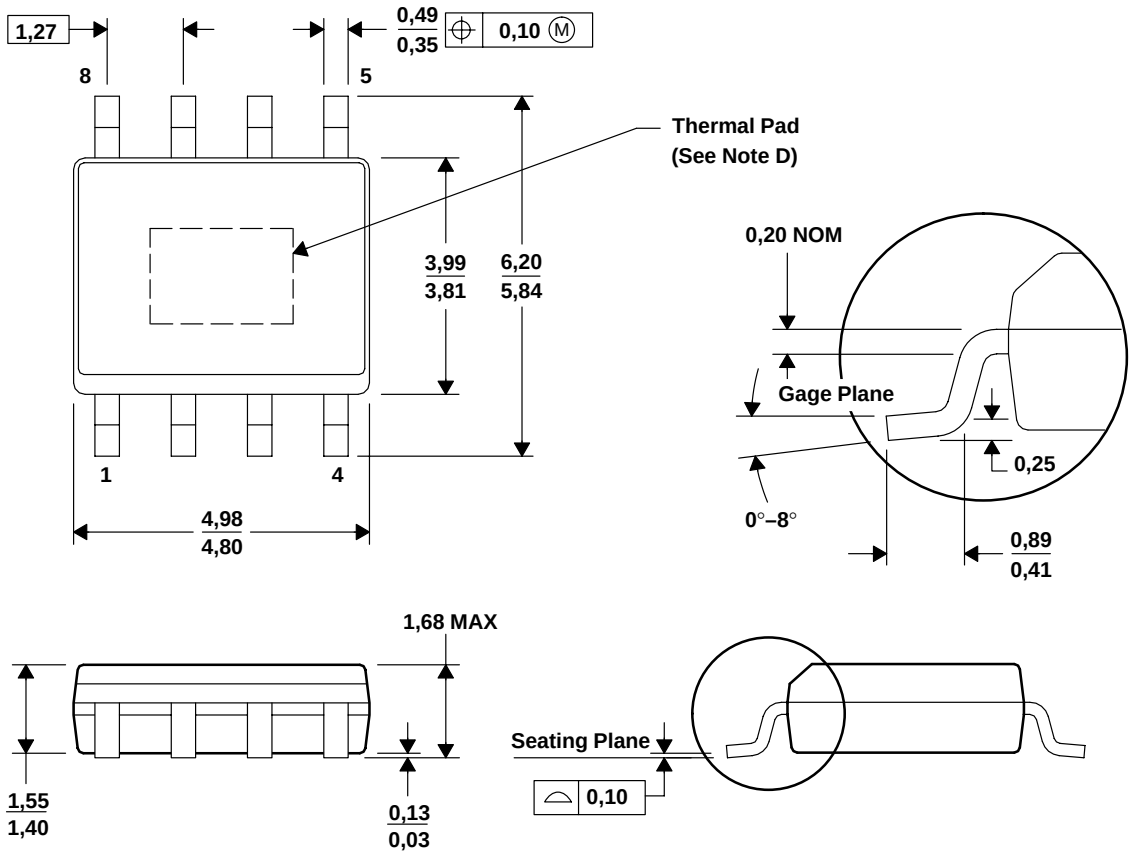

| DIM \ PINS ** | 8 | 14 | 16 |
|---|---|---|---|
| A MAX | 0.197 (5,00) | 0.344 (8,75) | 0.394 (10,00) |
| A MIN | 0.189 (4,80) | 0.337 (8,55) | 0.386 (9,80) |

**4040047/D 10/96**

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
D. Falls within JEDEC MS-012

## MECHANICAL DATA

**DDA (S–PDSO–G8)** **Power PAD™ PLASTIC SMALL-OUTLINE**




NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. The package thermal performance may be enhanced by bonding the thermal pad to an external thermal plane. This pad is electrically and thermally connected to the backside of the die and possibly selected leads.

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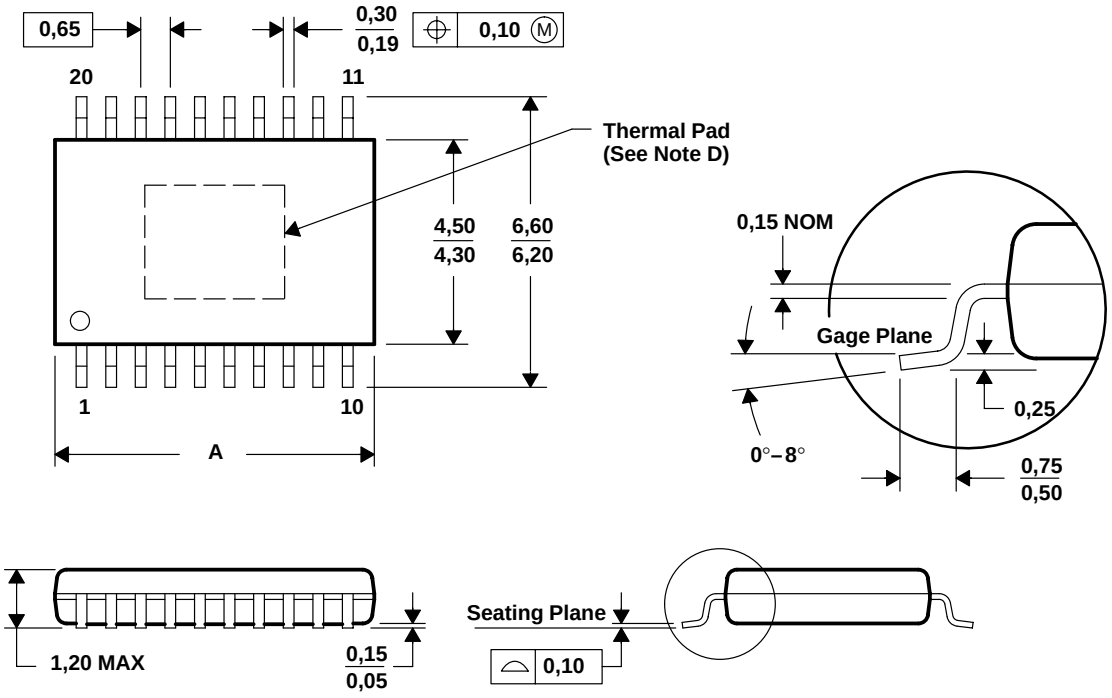
## MECHANICAL INFORMATION

**PWP (R-PDSO-G**)** **PowerPAD™ PLASTIC SMALL-OUTLINE PACKAGE**

**20-PIN SHOWN**




| DIM \ PINS ** | 14 | 16 | 20 | 24 | 28 |
|---|---|---|---|---|---|
| A MAX | 5,10 | 5,10 | 6,60 | 7,90 | 9,80 |
| A MIN | 4,90 | 4,90 | 6,40 | 7,70 | 9,60 |

**4073225/E 03/97**

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusions.
D. The package thermal performance may be enhanced by bonding the thermal pad to an external thermal plane. This pad is electrically and thermally connected to the backside of the die and possibly selected leads.
E. Falls within JEDEC MO-153

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