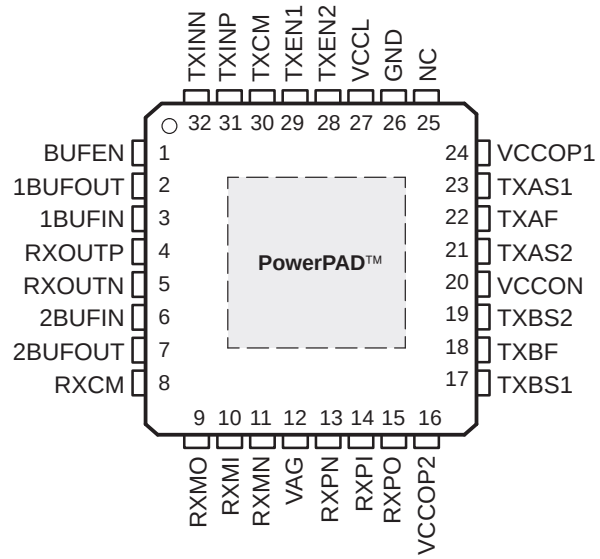
- **Full Rate ADSL Central Office Line Driver/Receiver for POTS Applications**
- **15-V Single Supply Operation**
- **Low 1.1-W Total Power Consumption**
  - **− 0.9-W Transmit Drivers**
  - **− 0.2-W Receive Channel**
- **Active Termination Differential Line Drivers**
  - **− No Line Matching Resistors Reduces Output Voltage and Power Consumption by up to 50%**
- **Integrated Differential Receivers**
- **Includes Analog Filters in Both Transmit and Received Channels**
- **Multiple Power Saving Modes**
  - **− Bias Current Is Adjustable in 20% Increments to Allow Lower Power Modes for Short Line Lengths**

**VFP PACKAGE**
**(TOP VIEW)**

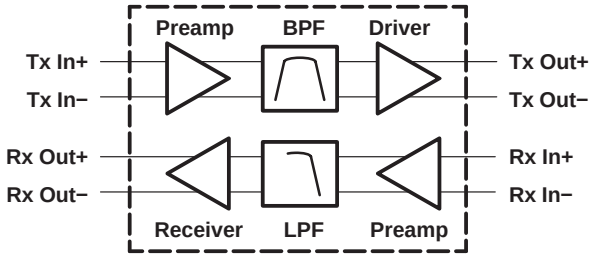



NC − No internal connection

## description

The THS7102 is a low power differential ADSL (POTS) central office line interface driver/receiver. It features active termination drivers that eliminate the matching resistors required with traditional ADSL line drivers. Removal of the matching resistors allows the THS7102 to output nearly half the output voltage as compared with traditional drivers, resulting in power savings of up to 50% . The lower output voltage levels resulting from the active termination also allow the THS7102 to operate on a single 15-V supply, easing power supply requirements.

## simplified block diagram




The THS7102 also features integrated differential receivers to reduce the component count on multichannel ADSL line cards. To reduce valuable PCB space further, the transmit path integrates a band-pass filter while the receive path integrates a low-pass filter. Four power-saving modes are featured on this device, allowing it to operate at lower power levels for shorter line lengths.

**THS7102 Features**

| Device | Application | Transmit Bandpass Filter† | Receiver Lowpass Filter |
|---|---|---|---|
| THS7102 | ADSL (POTS) | 152 kHz to 1.3 MHz | 146 kHz |

† When used in conjunction with the appropriate input capacitor (see the functional block diagram information)

CAUTION: The THS7102 provides ESD protection circuitry. However, permanent damage can still occur if the device is subjected to high-energy electrostatic discharge. Proper ESD precautions are recommended to avoid any performance degradation or loss of functionality.

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.

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**AVAILABLE OPTIONS**

| $T_A$ | PACKAGED DEVICES |
|---|---|
| | PowerPAD (VFP) |
| 0°C to 70°C | THS7102CVFP |
| −40°C to 85°C | THS7102IVFP |

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

Supply voltage, VCCL, VCCOP1, VCCOP2 (see Note 1) . . . . . 17 V
Input voltage, $V_I$ . . . . . GND, VCCL, VCCOPx
Output current, $I_O$ (see Note 2): Tx outputs . . . . . 400 mA
Rx outputs . . . . . 50 mA
BUF outputs . . . . . 50 mA
Differential input voltage, $V_{ID}$ . . . . . ±3 V
ESD rating: HBM . . . . . 2 kV
CDM . . . . . 500 V
MM . . . . . 200 V
Total power dissipation at (or below) 25°C free-air temperature
(see Note 2) . . . . . See Dissipation Rating Table
Maximum junction temperature, $T_J$ . . . . . 150°C
Operating free-air temperature, $T_A$: C-suffix . . . . . 0°C to 70°C
I-suffix . . . . . −40°C to 85°C
Storage temperature, $T_{stg}$ . . . . . −65°C to 125°C
Lead temperature 1,6 mm (1/16 in) 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.

NOTES: 1. VCCL must always be equal to VCCOP1 and VCCOP2
2. The THS7102 incorporates a PowerPAD™ on the underside of the chip. This acts as a heatsink and must be connected to a thermally dissipative plane for proper power dissipation. Failure to do so may result in exceeding the maximum junction temperature which could permanently damage the device.

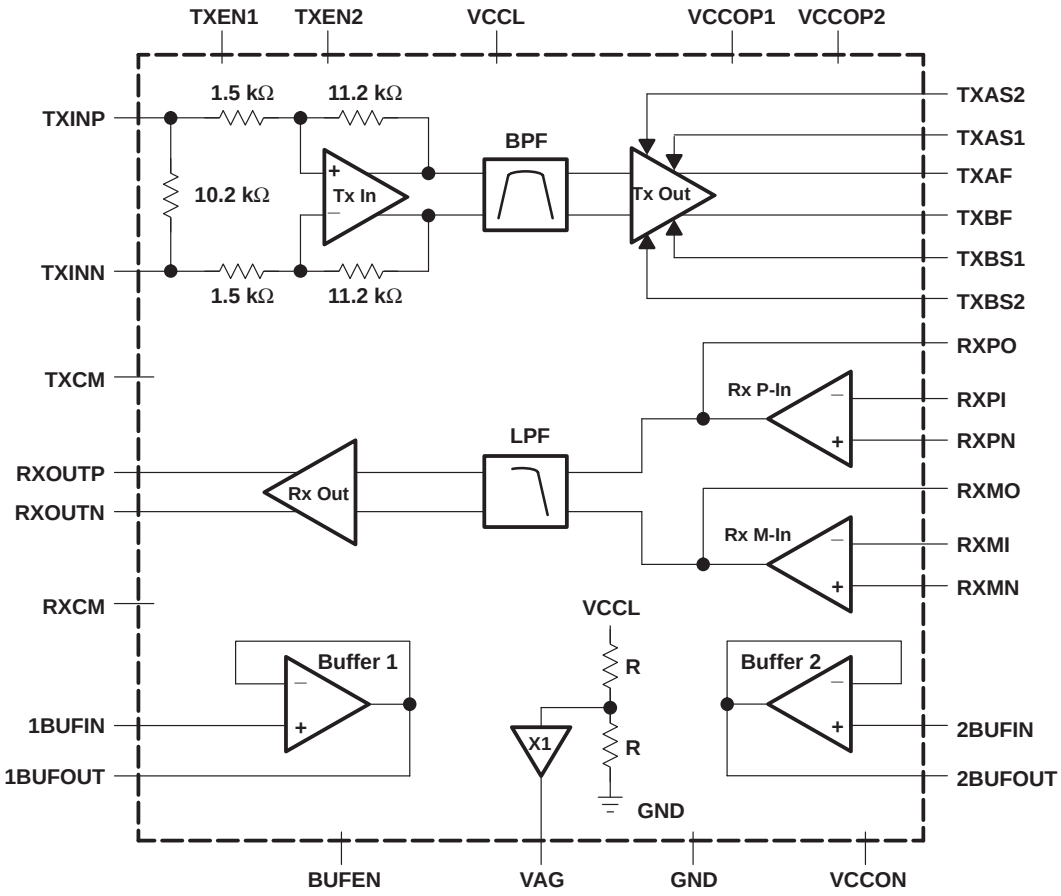
**DISSIPATION RATING TABLE§**

| PACKAGE | $\theta_{JA}$ (°C/W) | $\theta_{JC}$ (°C/W) | $T_A$ = 25°C¶ POWER RATING | $T_A$ = 70°C¶ POWER RATING | $T_A$ = 85°C¶ POWER RATING |
|---|---|---|---|---|---|
| VFP | 29.4 | 0.96 | 3.57 W | 2.04 W | 1.53 W |

§ This data was taken using 2 oz. trace and copper pad that is soldered directly to a JEDEC standard 4 layer 3 in × 3 in PCB.

¶ The power rating is determined with a junction temperature of 130°C. This is the junction temperature at which distortion begins to substantially increase. Thermal management of the PCB should strive to keep the junction temperature at or below 125°C for the best performance.

## functional block diagram




The THS7102 is designed to implement full-rate ADSL signals over the same line as POTS signals at the central office (CO). The THS7102 transmit BPF consists of a low-pass filter and a high-pass filter. The low-pass filter portion of the BPF is comprised of a third order Chebyshev filter with a 0.33-dB passband ripple and a breakpoint frequency of 1.3 MHz. The high-pass portion of the BPF is a 0.33-dB passband ripple Chebyshev with a breakpoint frequency at 151.7 kHz. This high-pass section requires that a 680-pF capacitor be used at each transmit input (TXINP and TXINN) for the appropriate Chebyshev response. Together the LPF and HPF form a bandpass filter with a passband ripple of about 0.6 dB. The THS7102 receive LPF is comprised of a fourth order Chebyshev filter with a 0.25-dB passband ripple and a breakpoint frequency of 146 kHz.

**NOTE:**

The definition of breakpoint frequency is the frequency at which the attenuation leaves the ripple band.

## Terminal Functions

| TERMINAL | | I/O | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| BUFEN | 1 | I | Buffer enable − enables buffers 1 and 2 |
| 1BUFOUT | 2 | O | Buffer 1 output |
| 1BUFIN | 3 | I | Buffer 1 input |
| 2BUFIN | 6 | I | Buffer 2 input |
| 2BUFOUT | 7 | O | Buffer 2 output |
| GND | 26 | I | Ground |
| NC | 25 | | No connect |
| RXCM | 8 | O | Receive channel common-mode voltage decoupling node |
| RXMO | 9 | O | Negative receiver preamp output |
| RXMI | 10 | I | Negative receiver preamp inverting input |
| RXMN | 11 | I | Negative receiver preamp noninverting input |
| RXOUTP | 4 | O | Receive channel positive output |
| RXOUTN | 5 | O | Receive channel negative output |
| RXPI | 14 | I | Positive receiver preamp inverting input |
| RXPN | 13 | I | Positive receiver preamp noninverting input |
| RXPO | 15 | O | Positive receiver preamp output |
| TXAF | 22 | O | Driver A output |
| TXBF | 18 | O | Driver B output |
| TXAS1 | 23 | I | Driver A sense point 1 |
| TXAS2 | 21 | I | Driver A sense point 2 |
| TXBS1 | 17 | I | Driver B sense point 1 |
| TXBS2 | 19 | I | Driver B sense point 2 |
| TXCM | 30 | O | Transmit channel common mode decoupling node |
| TXEN1 | 29 | I | Transmit enable 1 |
| TXEN2 | 28 | I | Transmit enable 2 |
| TXINN | 32 | I | Transmit channel negative input |
| TXINP | 31 | I | Transmit channel positive input |
| VAG | 12 | O | Virtual analog ground − is at VCCL/2 |
| VCCL | 27 | I | $V_{CC}$ to low level circuitry |
| VCCON | 20 | I | Output stage negative supply − tie to ground |
| VCCOPx | 16, 24 | I | Output stage positive $V_{CC}$ supply |

## recommended operating conditions

| | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|
| Supply voltage | VCCL, VCCOP1, VCCOP2 | 7.5 | 15 | 16 | V |
| Operating free-air temperature, $T_A$ | I−suffix | −40 | | 85 | °C |
| | C−suffix | 0 | | 70 | |

## driver characteristics, VCCL = VCCOPx = 15 V, VCCON = GND, $R_S$ = 1.35 Ω, N = 1, $R_L$ = 27 Ω†, $C_i$ = 0.1 μF, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $R_{IN}$–Tx | Input resistance (single-ended) | | | 1.13 | 1.16 | 1.19 | kΩ |
| $V_A$ | Output voltage | f = 1 MHz, | THD ≤ −31 dBc | 23.8 | 24.4 | | $V_{pp}$ |
| $V_A/V_{IN}$ | Gain (see Note 3 and Figure 1) | f = 1 MHz | | 18.9 | 19.2 | 19.5 | dB |
| | | f ≅ 150 kHz (Peak Frequency) | | 22.4 | 22.7 | 23 | |
| $V_B/V_{IN}$ | Gain (see Note 3 and Figure 1) | f = 1 MHz | | 18.1 | 18.4 | 18.7 | dB |
| | | f ≅ 150 kHz (Peak Frequency) | | 21.6 | 21.9 | 22.2 | |
| | Differential output noise | 30 kHz | | | 55 | | nV/√Hz |
| | | 100 kHz | | | 85 | | |
| | | 138 kHz | | | 118 | | |
| $Z_o$ | Output impedance‡ | f = 20 kHz to 1.1 MHz | | | † | | Ω |
| | Filter corner frequency | HPF, | $C_i$ = 0.1 μF | 100 | 107 | 114 | kHz |
| | | LPF | | 1.1 | 1.3 | 1.65 | MHz |
| | Out of band rejection (relative to the input signal) | $V_O$ at f = 40 kHz | $C_i$ = 0.1 μF | 0 | −2 | | dB |
| | | $V_O$ at f = 6 MHz | | −17.5 | −20.5 | | |
| | Channel-to-channel mismatch | f = 100 kHz to 800 kHz | | −0.45 | 0 | 0.45 | dB |
| | | f = 900 kHz to 1.1 MHz | | −0.45 | 0 | 0.5 | |
| $I_{CCL}$ | Supply current | Off, TXEN1 = 0 | TXEN2 = 0 | 0.7 | 1 | 1.3 | mA |
| | | Low, TXEN1 = 1 | TXEN2 = 0 | 13.1 | 14.6 | 16.1 | |
| | | Med., TXEN1 = 1 | TXEN2 = 1 | 13.3 | 14.8 | 16.3 | |
| | | High, TXEN1 = 0 | TXEN2 = 1 | 13.5 | 15 | 16.5 | |
| $I_{CCOP}$ | Supply current | Off, TXEN1 = 0, | TXEN2 = 0 | 0 | 0.6 | 1.1 | mA |
| | | Low, TXEN1 = 1, | TXEN2 = 0 | 1.7 | 2.7 | 3.7 | |
| | | Med., TXEN1 = 1, | TXEN2 = 1 | 6 | 7.5 | 9 | |
| | | High, TXEN1 = 0, | TXEN2 = 1 | 11 | 13 | 15 | |

† The test circuit of $R_S$ = 1.35 Ω, N = 1, and $R_L$ = 27 Ω is equivalent to a standard ADSL circuit with $R_S$ = 1.35 Ω, N = 1.9, and $R_L$ = 100 Ω.
‡ Output impedance is given by $Z_o = 10 \times R_S$.
NOTES: 3. Due to the gain of the transmit path, the maximum input voltage should not exceed 3 $V_{pp}$ or clipping and distortion occurs.

## receiver characteristics, VCCL = VCCOPx = 15 V, VCCON = GND, $R_S$ = 1.35 Ω, N = 1, $R_L$ = 3.9 kΩ, $R_F$ = 5 kΩ, Gain = 26 dB, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_O$ | Output voltage | $V_I$ = 1 $V_{pp}$, f = 103.5 kHz | 19 | 20 | | $V_{pp}$ |
| | Output noise | At f = 30 kHz | | 77 | | nV/√Hz |
| | | At f = 130 kHz | | 72 | | |
| $V_n$ | Noise voltage (preamp input noise) | f = 20 kHz | | 2.3 | | nV/√Hz |
| $I_n$ | Noise current (preamp input noise) | f = 20 kHz | | 1.0 | | pA/√Hz |
| | Filter corner frequency | $V_I$ = 0.5 $V_{pp}$ | 137.5 | 146.3 | 155 | kHz |
| | Out of band rejection (relative to input point A) See Figure 1 | $V_O$ at f = 400 kHz | −11.7 | −13 | | dB |
| | In-band ripple | $V_O$ at f = 55 kHz and 103.5 kHz | | 0.2 | 0.5 | dB |
| | Channel-to-channel mismatch | f = 10 kHz to 145 kHz | −0.2 | 0 | 0.2 | dB |

### transmit enable characteristics (TXEN1, TXEN2), VCCL = VCCOPx = 15 V, VCCON = GND, $R_S$ = 1.35 Ω, N = 1, $T_A$ = 25°C

| BUFEN | TXEN1 | TXEN2 | FUNCTION | DESCRIPTION |
|---|---|---|---|---|
| X | 0 | 0 | Tx OFF | Device completely powered down |
| X | 0 | 1 | Tx ON − 100% bias | Full power |
| X | 1 | 1 | Tx ON − Medium bias | Medium power |
| X | 1 | 0 | Tx ON − Low bias | Low power |
| 0 | X | X | Buffers off | Conserves power when buffers are not required |
| 1 | X | X | Buffers enabled | Useful for extra RX filtering |

NOTE: The default state shall be a logic one (1).

### logic control characteristics, VCCL = VCCOPx = 15 V, VCCON = GND, $R_S$ = 1.35 Ω, N = 1, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $I_{IH}$ | TXEN1 | $V_{TXEN1}$ = 5 V | −5 | 0 | 5 | µA |
| | TXEN2 | $V_{TXEN2}$ = 5 V | −5 | 0 | 5 | |
| | BUFEN | $V_{BUFEN}$ = 5 V | −5 | 0 | 5 | |
| $I_{IL}$ | TXEN1 | $V_{TXEN1}$ = 0 V | −70 | −50 | −30 | µA |
| | TXEN2 | $V_{TXEN2}$ = 0 V | −70 | −55 | −30 | |
| | BUFEN | $V_{BUFEN}$ = 0 V | −70 | −50 | −30 | |
| $V_{IH}$ | All logic control pins | | | ≥2.3 | | V |
| $V_{IL}$ | All logic control pins | | | ≤0.8 | | V |

### miscellaneous characteristics, VCCL = VCCOPx = 15 V, VCCON = GND, $R_S$ = 1.35 Ω, N = 1, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_O$ | Output voltage, VAG | | 7.4 | 7.5 | 7.6 | V |
| $V_O$ | Output voltage, buffer | $V_I$ = 7.5 V | 7.0 | 7.5 | 8.0 | V |

## TYPICAL CHARACTERISTICS

**TRANSMIT DIFFERENTIAL OUTPUT NOISE vs FREQUENCY**

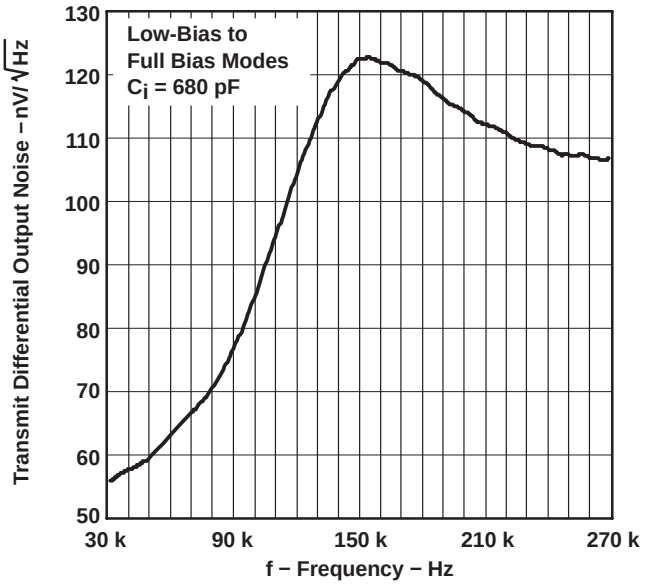



Figure 1

**TRANSMIT DIFFERENTIAL OUTPUT NOISE vs FREQUENCY**

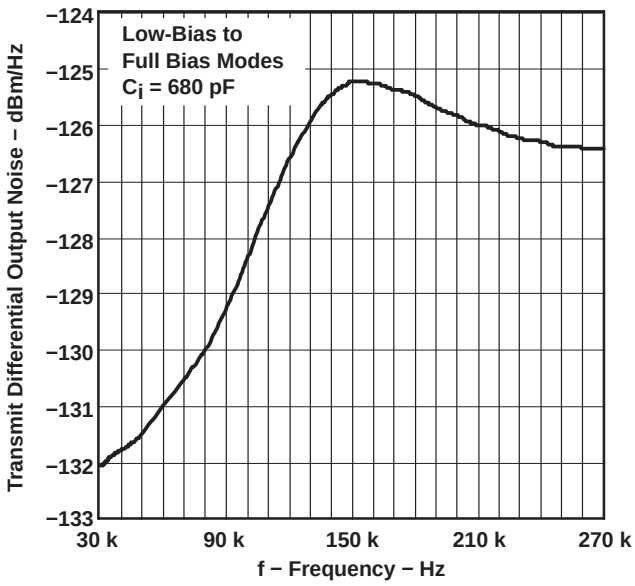
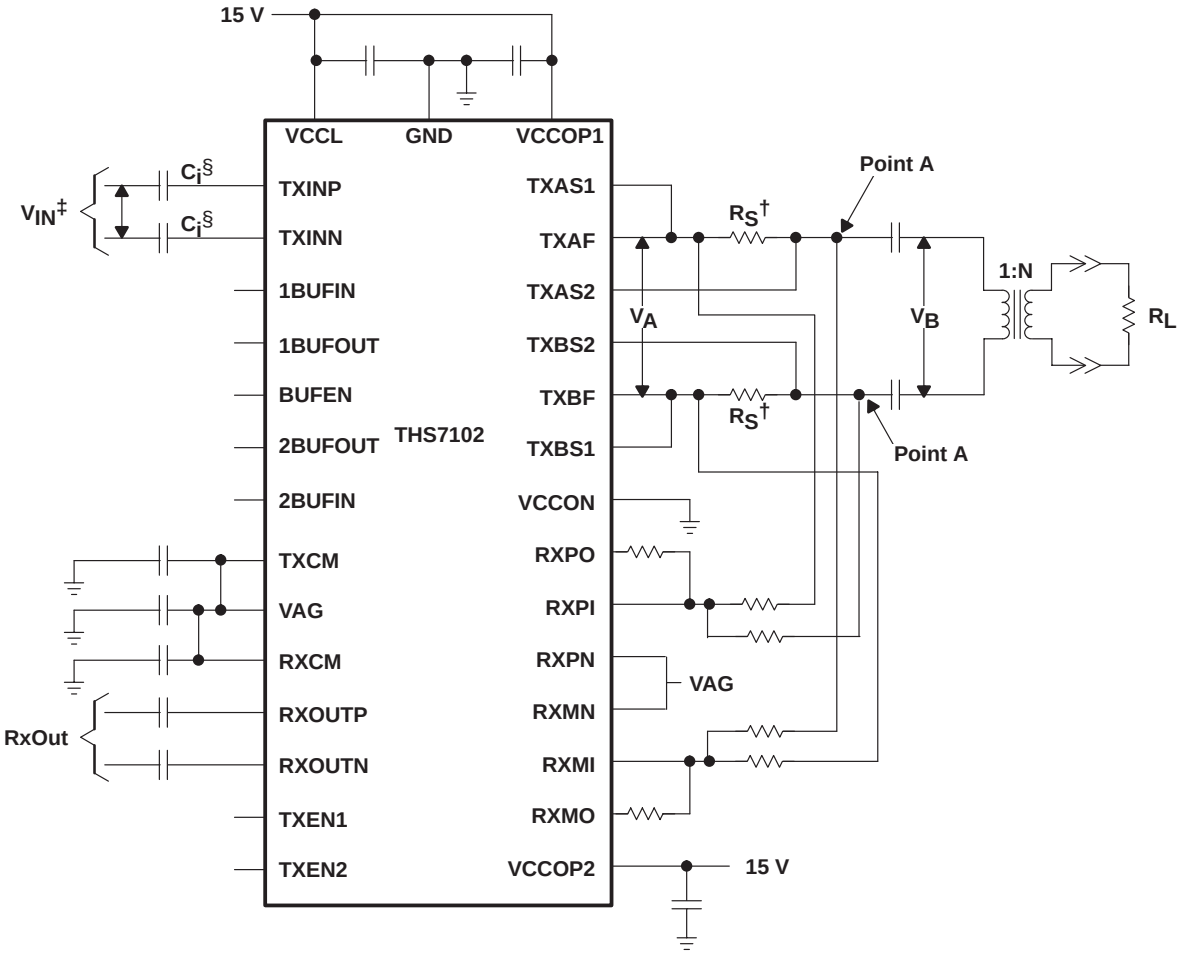



Figure 2

## APPLICATION INFORMATION

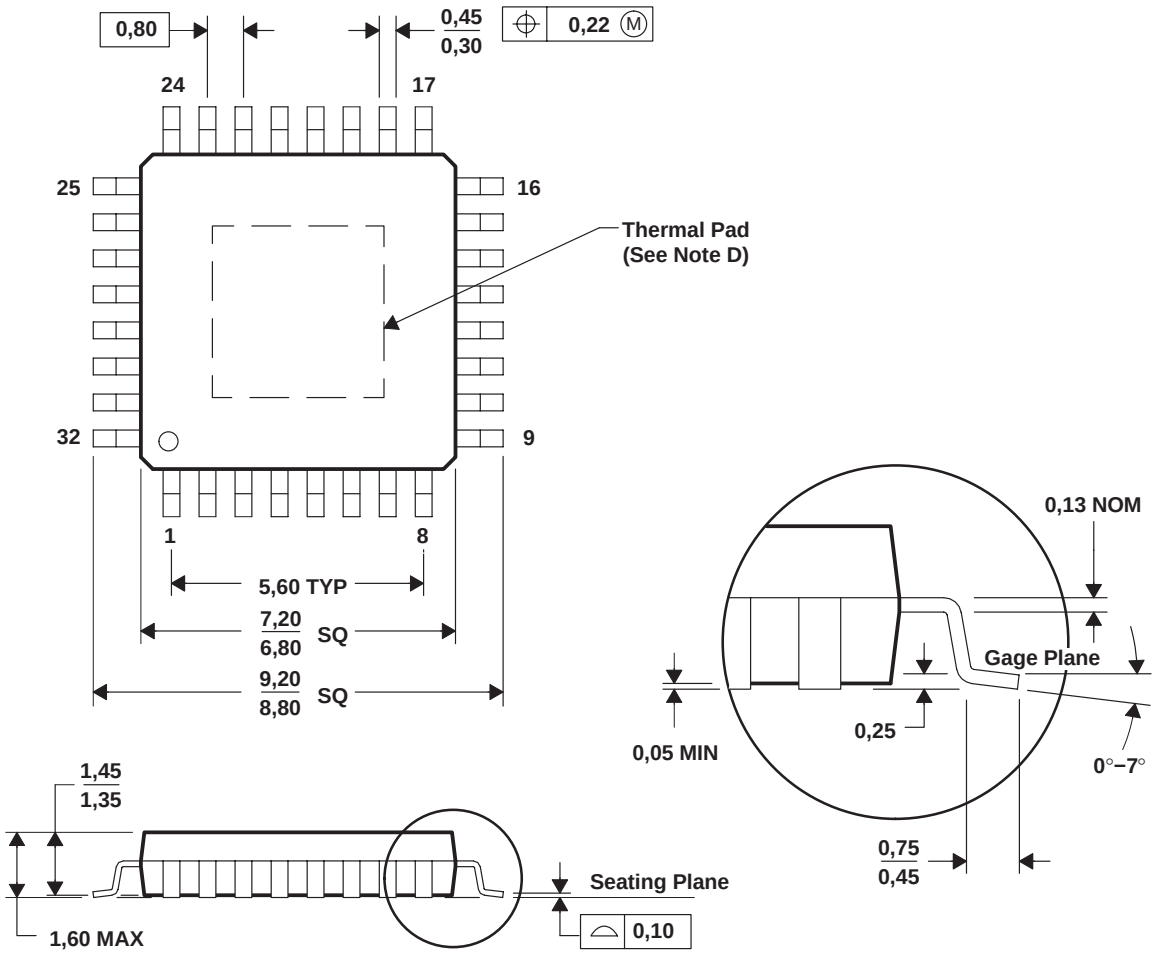



† Output impedance of transmit driver at point A = 10 × $R_S$
‡ Maximum input of $V_{IN}$ = 3 $V_{pp}$.
§ In ADSL systems, it is recommended to use $C_i$ = 680 pF for the THS7102. For testing purposes, use $C_i$ = 0.1 µF

**Figure 3. Typical THS7102 Circuit Configuration**

## MECHANICAL DATA

**VFP (S-PQFP-G32)** **PowerPAD™ PLASTIC QUAD FLATPACK**




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.
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 MS-026

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