



## DIGITAL AMPLIFIER POWER STAGE

### FEATURES

- 100-W RMS Power (BTL) Into 4  $\Omega$  With Less Than 10% THD+N
- 80-W RMS Power (BTL) Into 4  $\Omega$  With Less Than 0.2% THD+N
- 0.09% THD+N at 1 W Into 4  $\Omega$
- Power Stage Efficiency Greater Than 90% Into 4- $\Omega$  Load
- Self-Protecting Design
- Industrial Temperature Rating
- 36-Pin PSOP3 Package
- 3.3-V Digital Interface
- EMI Compliant When Used With Recommended System Design

### APPLICATIONS

- DVD Receiver
- Home Theatre

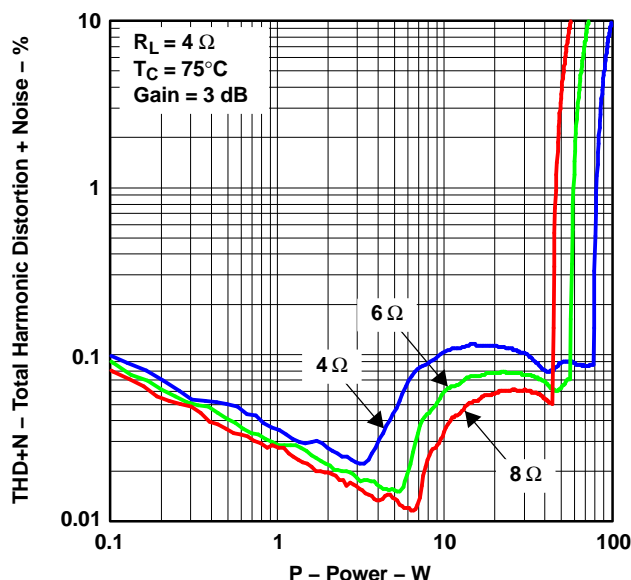
- Mini/Micro Component Systems
- Internet Music Appliance

### DESCRIPTION

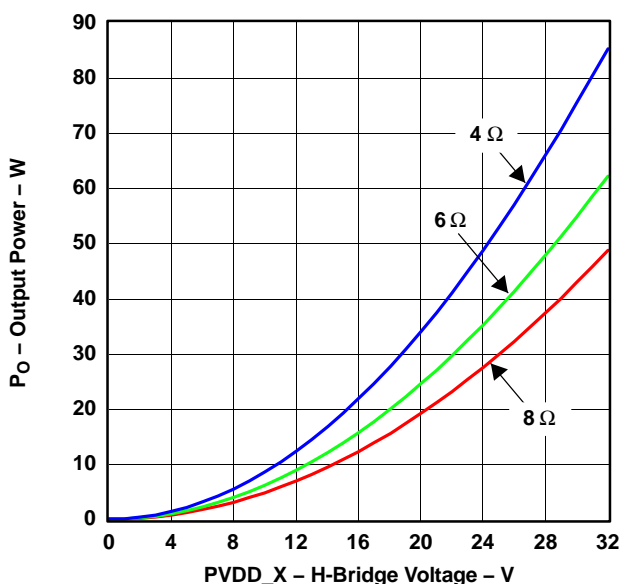
The TAS5121I is a high-performance, digital-amplifier power stage designed to drive a 4- $\Omega$  speaker up to 100 W. The TAS5121I is rated for operation at industrial temperatures. The device incorporates PurePath Digital™ technology and can be used with a TI audio pulse-width modulation (PWM) processor and a simple passive demodulation filter to deliver high-quality, high-efficiency, digital-audio amplification.

The efficiency of this digital amplifier can be greater than 90%, depending on the system design. Overcurrent protection, overtemperature protection, and undervoltage protection are built into the TAS5121I, safeguarding the device and speakers against fault conditions that could damage the system.

TOTAL HARMONIC DISTORTION + NOISE  
VS  
POWER



UNCLIPPED OUTPUT POWER  
VS  
H-BRIDGE VOLTAGE



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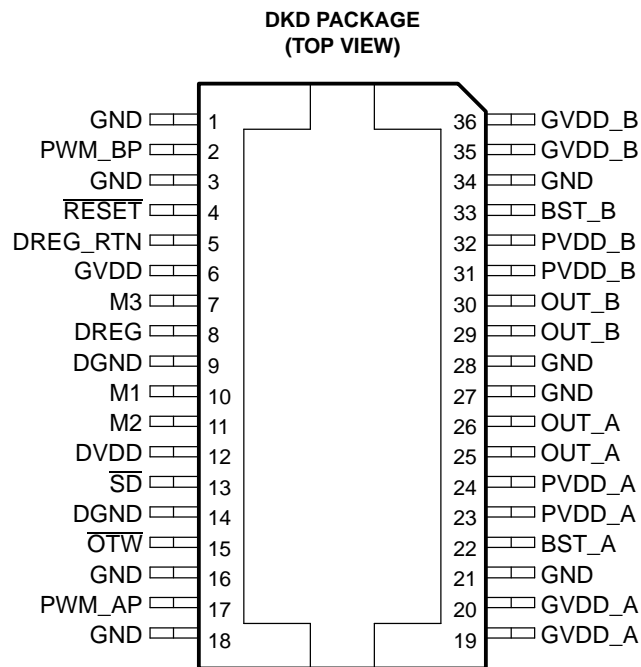


These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## GENERAL INFORMATION

### Terminal Assignment

The TAS5121I is offered in a thermally enhanced 36-pin PSOP3 (DKD) package. The DKD package has the thermal pad on top.



### ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range unless otherwise noted<sup>(1)</sup>

|   |                        |
|---|------------------------|
| DVDD TO DGND                                      | –0.3 V to 4.2 V        |
| GVDD_x TO GND                                     | 14.2 V                 |
| PVDD_X TO GND (dc voltage)                        | 33.5 V                 |
| PVDD_X TO GND <sup>(2)</sup>                      | 48 V                   |
| OUT_X TO GND (dc voltage)                         | 33.5 V                 |
| OUT_X TO GND <sup>(2)</sup>                       | 48 V                   |
| BST_X TO GND (dc voltage)                         | 46 V                   |
| BST_X TO GND <sup>(2)</sup>                       | 53 V                   |
| PWM_XP, RESET, M1, M2, M3, SD, OTW                | –0.3 V to DVDD + 0.3 V |
| T <sub>J</sub> Maximum junction temperature range | –40°C to 150°C         |
| Storage temperature                               | –40°C to 125°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) The duration should be less than 100 ns (see application note [SLEA025](#)).

## ORDERING INFORMATION

| T <sub>A</sub> | PACKAGE      | TRANSPORT MEDIA | DESCRIPTION  |
|----------------|--------------|-----------------|--------------|
| –40°C to 85°C  | TAS5121IDKD  | Tube            | 36-pin PSOP3 |
| –40°C to 85°C  | TAS5121IDKDR | Tape and reel   | 36-pin PSOP3 |

## PACKAGE DISSIPATION RATINGS

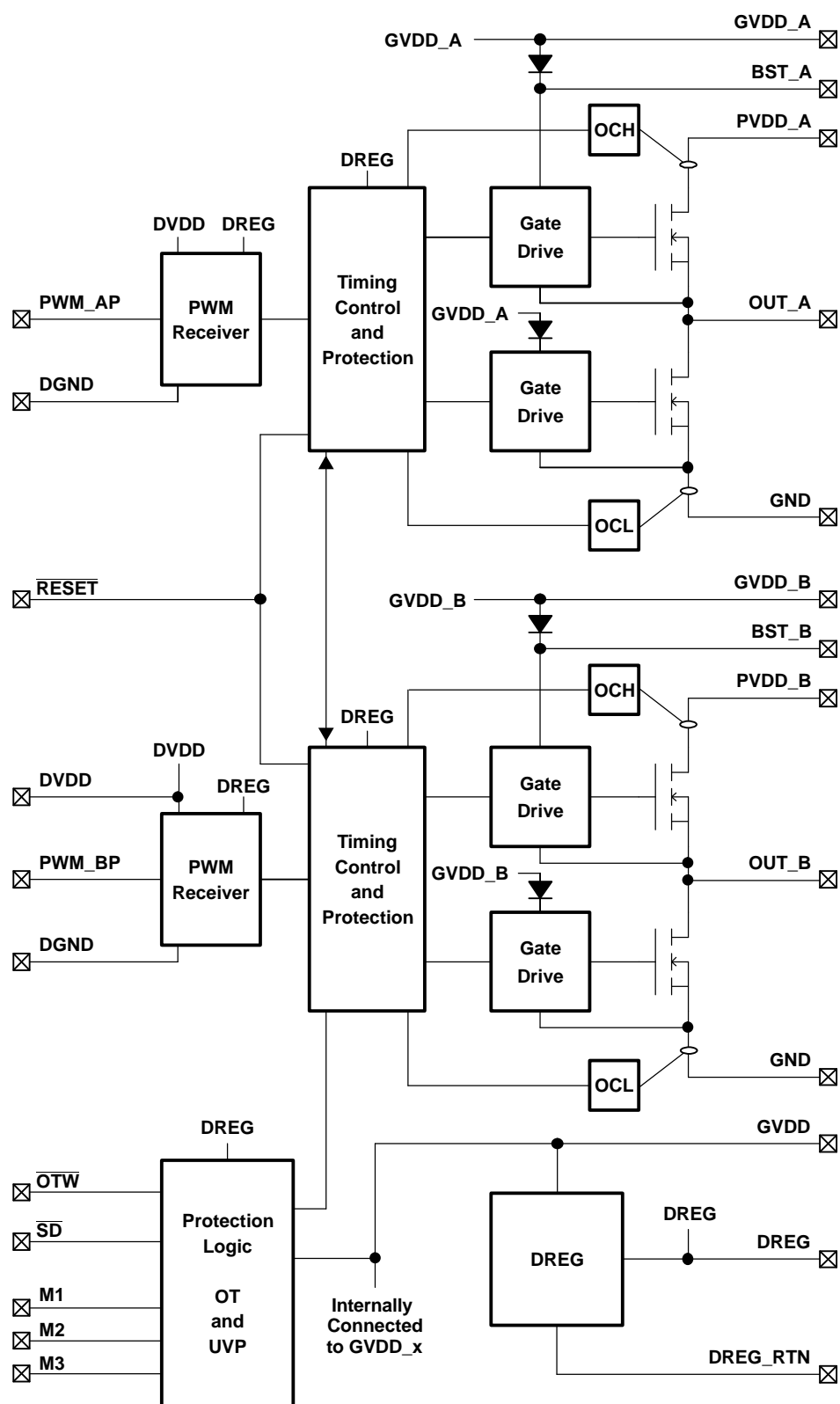
| PACKAGE          | R <sub>θJC</sub><br>(°C/W) | R <sub>θJA</sub><br>(°C/W) |
|------------------|----------------------------|----------------------------|
| 36-Pin DKD PSOP3 | 0.85                       | See <sup>(1)</sup>         |

- (1) The TAS5121I package is thermally enhanced for conductive cooling using an exposed metal pad area. It is impractical to use the devices with the pad exposed to ambient air as the only heat sinking of the device. Therefore R<sub>θJA</sub>, a system parameter that characterizes the thermal treatment, is provided in the *Thermal Information* section. This information should be used as a reference to calculate the heat dissipation ratings for a specific application.

## Terminal Functions

| TERMINAL |                              | FUNCTION <sup>(1)</sup> | DESCRIPTION  |
|----------|------------------------------|-------------------------|--|
| NAME     | DKD                          |                         |  |
| BST_A    | 22                           | P                       | High-side bootstrap (BST) supply, external resistor and capacitor to OUT_A required                          |
| BST_B    | 33                           | P                       | High-side bootstrap (BST) supply, external resistor and capacitor to OUT_B required                          |
| DGND     | 9, 14                        | P                       | I/O reference ground   |
| DREG     | 8                            | P                       | Digital supply-voltage regulator-decoupling pin, 1-μF capacitor connected to DREG_RTN                        |
| DREG_RTN | 5                            | P                       | Decoupling return pin  |
| DVDD     | 12                           | P                       | I/O reference supply input: 100 Ω to DREG, decoupled to GND, 0.1-μF capacitor connected to GND               |
| GND      | 1, 3, 16, 18, 21, 27, 28, 34 | P                       | Power ground, connected to system GND  |
| GVDD     | 6                            | P                       | Local GVDD decoupling pin  |
| GVDD_A   | 19, 20                       | P                       | Gate-drive input voltage   |
| GVDD_B   | 35, 36                       | P                       | Gate-drive input voltage   |
| M1       | 10                           | I                       | Protection-mode selection pin, connect to GND  |
| M2       | 11                           | I                       | Protection-mode selection pin, connect to DREG   |
| M3       | 7                            | I                       | Output-mode selection pin; connect to GND  |
| OTW      | 15                           | O                       | Overtemperature warning output, open-drain with internal pullup, asserted low when temperature exceeds 115°C |
| OUT_A    | 25, 26                       | O                       | Output, half-bridge A  |
| OUT_B    | 29, 30                       | O                       | Output, half-bridge B  |
| PVDD_A   | 23, 24                       | P                       | Power supply input for half-bridge A   |
| PVDD_B   | 31, 32                       | P                       | Power supply input for half-bridge B   |
| PWM_AP   | 17                           | I                       | PWM input signal, half-bridge A  |
| PWM_BP   | 2                            | I                       | PWM input signal, half-bridge B  |
| RESET    | 4                            | I                       | Reset signal, active-low   |
| SD       | 13                           | O                       | Shutdown signal for half-bridges A and B (open-drain with internal pullup)                                   |

- (1) I = input, O = Output, P = Power

**FUNCTIONAL BLOCK DIAGRAM**

## RECOMMENDED OPERATING CONDITIONS

|                |   |                                    | MIN  | NOM  | MAX  | UNIT |
|----------------|---|------------------------------------|------|------|------|------|
| DVDD           | Digital supply <sup>(1)</sup>                       | Relative to DGND                   | 3    | 3.3  | 3.6  | V    |
| GVDD_x         | Supply for internal gate drive and logic regulators | Relative to GND                    | 10.8 | 12   | 13.2 | V    |
| PVDD_x         | Half-bridge supply                                  | Relative to GND, $R_L = 4\ \Omega$ | 0    | 30.5 | 32   | V    |
| T <sub>J</sub> | Junction temperature                                |                                    | 0    |      | 125  | °C   |

(1) It is recommended for DVDD to be connected to DREG via a 100- $\Omega$  resistor.

## ELECTRICAL CHARACTERISTICS

PVDD\_X = 30.5 V, GVDD\_x = 12 V, DVDD connected to DREG via a 100- $\Omega$  resistor,  $R_L = 4\ \Omega$ ,  $8X\ f_s = 384\ \text{kHz}$ , TAS5026 PWM processor, unless otherwise noted

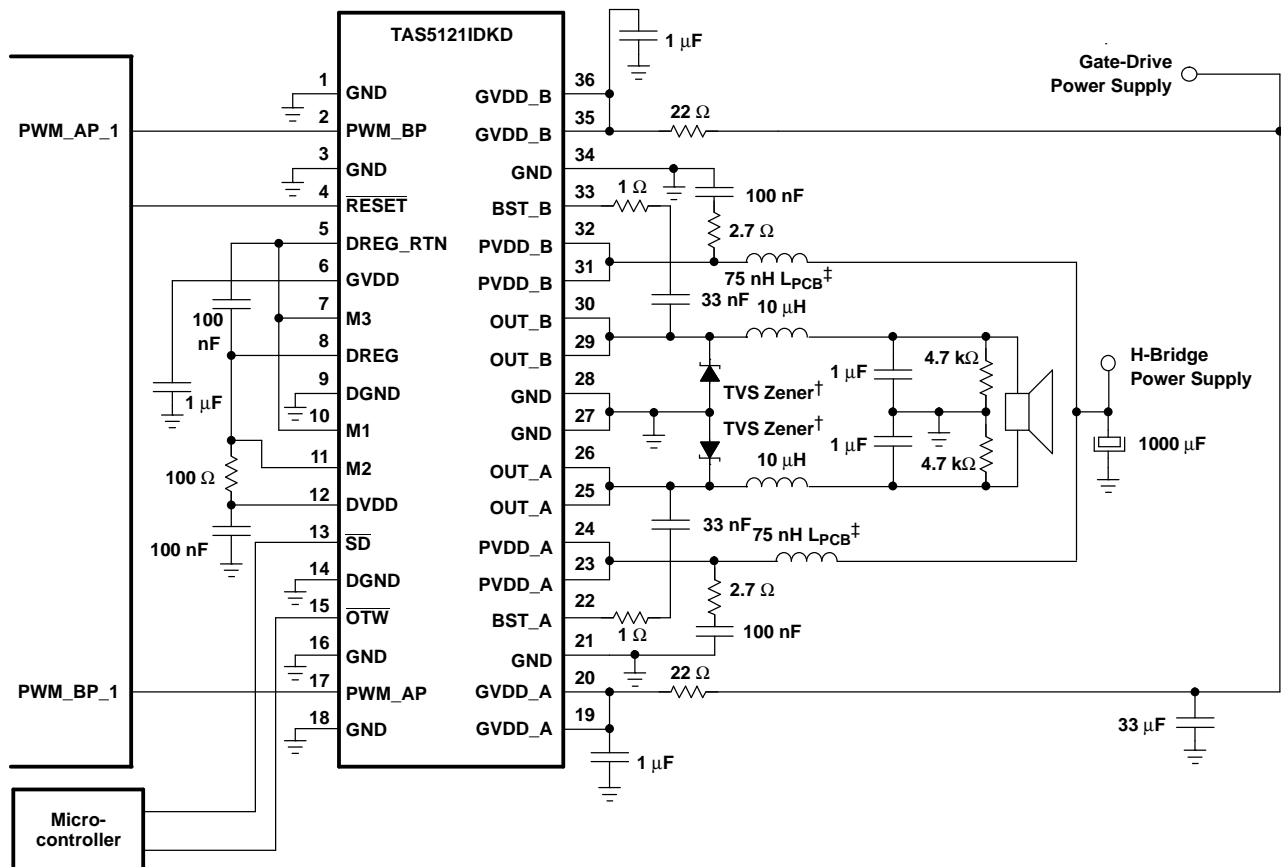
| SYMBOL   | PARAMETER                            | TEST CONDITIONS   | TYPICAL              | OVER TEMPERATURE     |                         |       |                 |
|--|--------------------------------------|---|----------------------|----------------------|-------------------------|-------|-----------------|
|  |                                      |   | T <sub>A</sub> =25°C | T <sub>A</sub> =25°C | T <sub>Case</sub> =75°C | UNITS | MIN/TYP/<br>MAX |
| AC PERFORMANCE, BTL Mode, 1 kHz                    |                                      |   |                      |                      |                         |       |                 |
| P <sub>O</sub>                                     | Output power                         | R <sub>L</sub> = 4 Ω, THD = 10%, AES17 filter                     |                      |                      | 100                     | W     | Typ             |
|  |                                      | R <sub>L</sub> = 4 Ω, THD = unclipped, AES17 filter               |                      |                      | 80                      | W     | Typ             |
|  |                                      | R <sub>L</sub> = 8 Ω, THD = unclipped, AD mode                    |                      |                      | 44                      | W     | Typ             |
| THD+N  | Total harmonic distortion + noise    | P <sub>O</sub> = 1 W/channel, R <sub>L</sub> = 4 Ω, AES17 filter  |                      |                      | 0.09                    | %     | Typ             |
|  |                                      | P <sub>O</sub> = 10 W/channel, R <sub>L</sub> = 4 Ω, AES17 filter |                      |                      | 0.15                    | %     | Typ             |
|  |                                      | P <sub>O</sub> = 80 W/channel, R <sub>L</sub> = 4 Ω, AES17 filter |                      |                      | 0.19                    | %     | Typ             |
| V <sub>n</sub>                                     | Output-integrated noise voltage      | A-weighted, R <sub>L</sub> = 4 Ω, 20 Hz to 20 kHz, AES17 filter   |                      |                      | 300                     | μV    | Max             |
| SNR  | Signal-to-noise ratio                | A-weighted, AES17 filter  |                      |                      | 95                      | dB    | Typ             |
| DR   | Dynamic range                        | f = 1 kHz, –60 dB, A-weighted, AES17 filter                       |                      |                      | 95                      | dB    | Typ             |
| INTERNAL VOLTAGE REGULATOR AND CURRENT CONSUMPTION |                                      |   |                      |                      |                         |       |                 |
| DREG   | Voltage regulator                    | I <sub>o</sub> = 1 mA   | 3.3                  |                      |                         | V     | Min             |
|  |                                      |   |                      |                      |                         | V     | Max             |
| IGVDD_x  | Total GVDD supply current, operating | f <sub>S</sub> = 384 kHz, no load, 50% duty cycle                 | 24                   | 30                   |                         | mA    | Max             |
| IDVDD  | DVDD supply current, operating       | f <sub>S</sub> = 384 kHz, no load                                 | 1                    | 5                    |                         | mA    | Max             |
| OUTPUT STAGE MOSFETs                               |                                      |   |                      |                      |                         |       |                 |
| R <sub>DSon,LS</sub>                               | Forward on-resistance, low side      | T <sub>J</sub> = 25°C   | 120                  | 132                  |                         | mΩ    | Max             |
| R <sub>DSon,HS</sub>                               | Forward on-resistance, high side     | T <sub>J</sub> = 25°C   | 120                  | 132                  |                         | mΩ    | Max             |
| INPUT/OUTPUT PROTECTION                            |                                      |   |                      |                      |                         |       |                 |
| V <sub>uvp,G</sub>                                 | Undervoltage protection limit, GVDD  |   | 7.6                  | 7                    |                         | V     | Min             |
|  |                                      |   |                      | 8.2                  |                         | V     | Max             |
| OTW  | Overtemperature warning              | Static  | 115                  |                      |                         | °C    | Typ             |
| OTE  | Overtemperature error                | Static  | 150                  |                      |                         | °C    | Typ             |
| OC   | Overcurrent protection               | See <sup>(1)</sup> .  | 9.5                  |                      |                         | A     | Min             |

(1) To optimize device performance and prevent overcurrent (OC) protection activation, the demodulation filter must be designed with special care. See *Demodulation Filter Design* in the *Application Information* section of this data sheet and consider the recommended inductors and capacitors for optimal performance. It is also important to consider PCB design and layout for optimum performance of the TAS5121I.

**ELECTRICAL CHARACTERISTICS (continued)**

PVDD\_X = 30.5 V, GVDD\_x = 12 V, DVDD connected to DREG via a 100-Ω resistor,  $R_L = 4\ \Omega$ ,  $8X\ f_s = 384\ \text{kHz}$ , TAS5026 PWM processor, unless otherwise noted

| SYMBOL  | PARAMETER  | TEST CONDITIONS       | TYPICAL              | OVER TEMPERATURE     |                         |       |                 |
|---|--|-----------------------|----------------------|----------------------|-------------------------|-------|-----------------|
|   |  |                       | T <sub>A</sub> =25°C | T <sub>A</sub> =25°C | T <sub>Case</sub> =75°C | UNITS | MIN/TYP/<br>MAX |
| STATIC DIGITAL INPUT SPECIFICATION, PWM, PROTECTION MODE SELECTION PINS, AND OUTPUT MODE SELECTION PINS |  |                       |                      |                      |                         |       |                 |
| V <sub>IH</sub>   | High-level input voltage   |                       |                      | 2                    |                         | V     | Min             |
|   |  |                       |                      | DVDD                 |                         | V     | Max             |
| V <sub>IL</sub>   | Low-level input voltage  |                       |                      | 0.8                  |                         | V     | Max             |
| Leakage   | Input leakage current  |                       |                      | −10                  |                         | μA    | Min             |
|   |  |                       |                      | 10                   |                         | μA    | Max             |
| OTW/SHUTDOWN (SD)   |  |                       |                      |                      |                         |       |                 |
|   | Internal pullup resistor from $\overline{\text{OTW}}$ and $\overline{\text{SD}}$ to DVDD |                       | 32                   | 22                   |                         | kΩ    | Min             |
| V <sub>OL</sub>   | Low-level output voltage   | I <sub>O</sub> = 1 mA |                      | 0.4                  |                         | V     | Max             |

**TYPICAL APPLICATION CONFIGURATION USED WITH TAS5026 PWM PROCESSOR**

† Voltage suppressor diodes: 1SMA33CAT3

‡  $L_{PCB}$  : Track in the PCB (1 mm wide and 50 mm long)

S0015–01

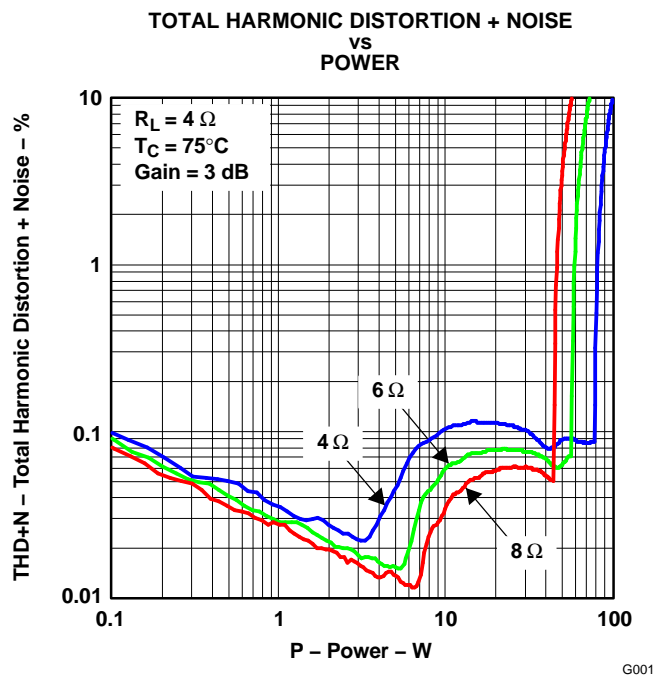


Figure 1.

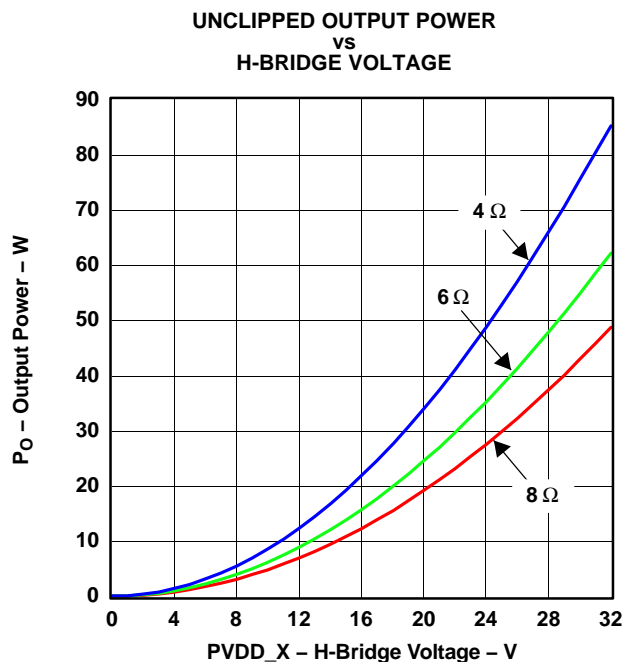


Figure 2.

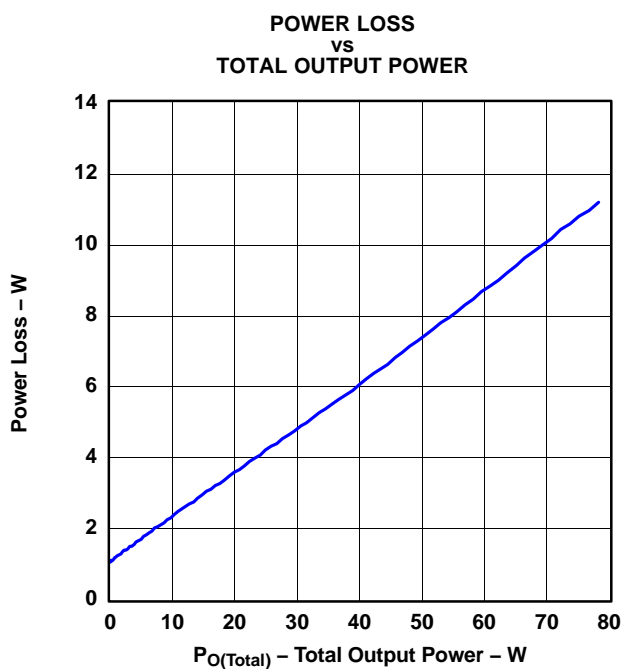


Figure 3.

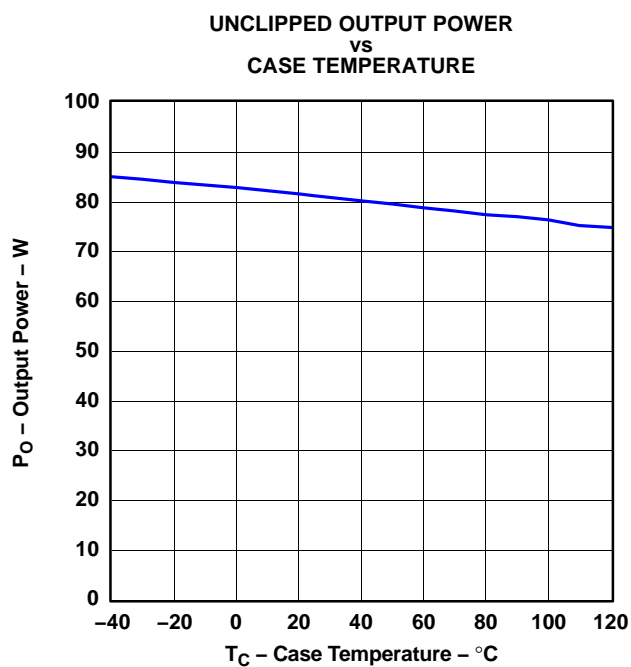


Figure 4.

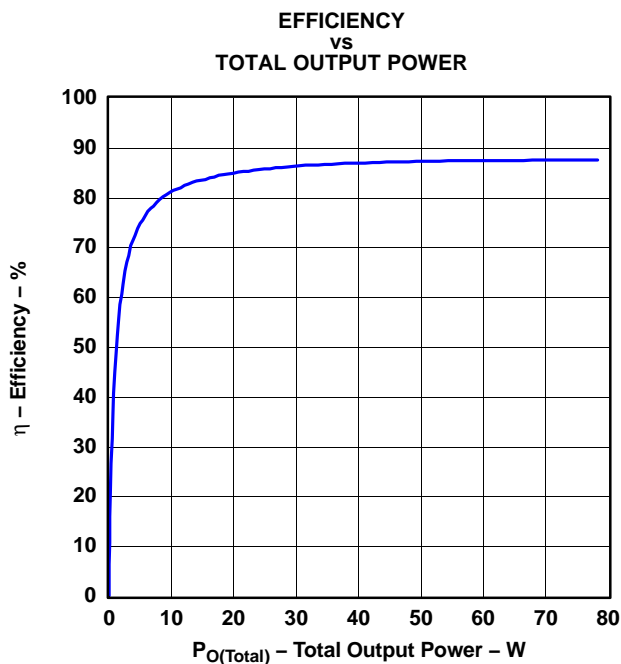
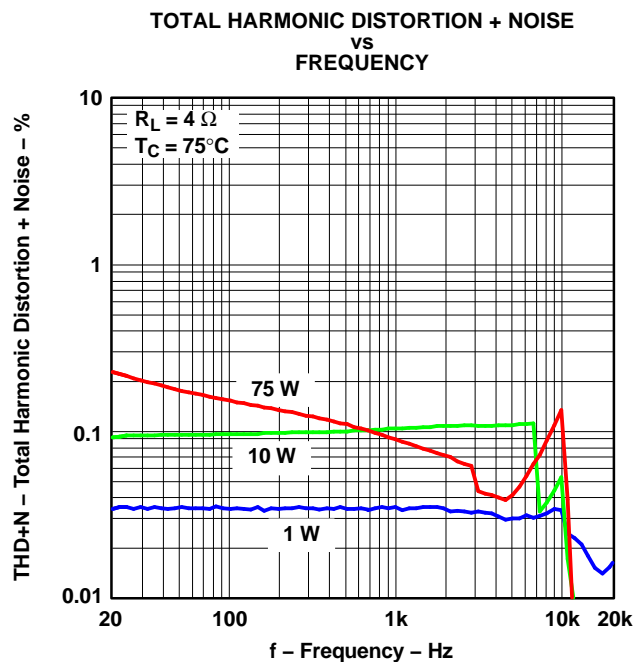


Figure 5.



G006

Figure 6.

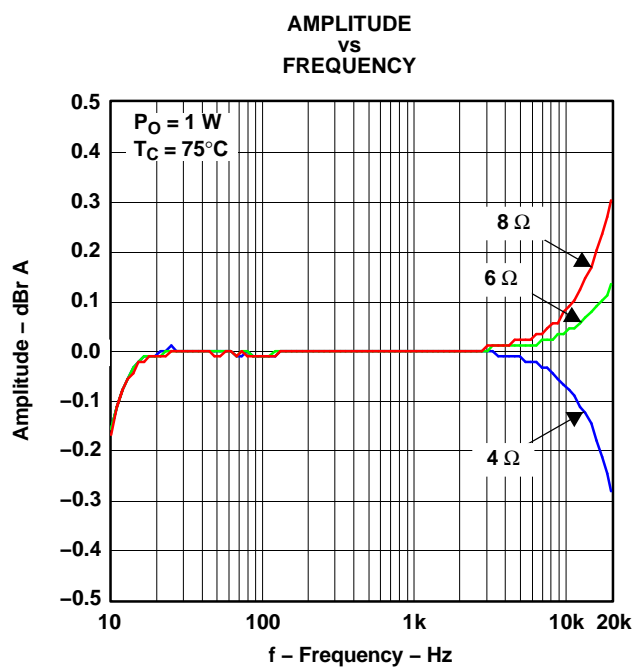


Figure 7.

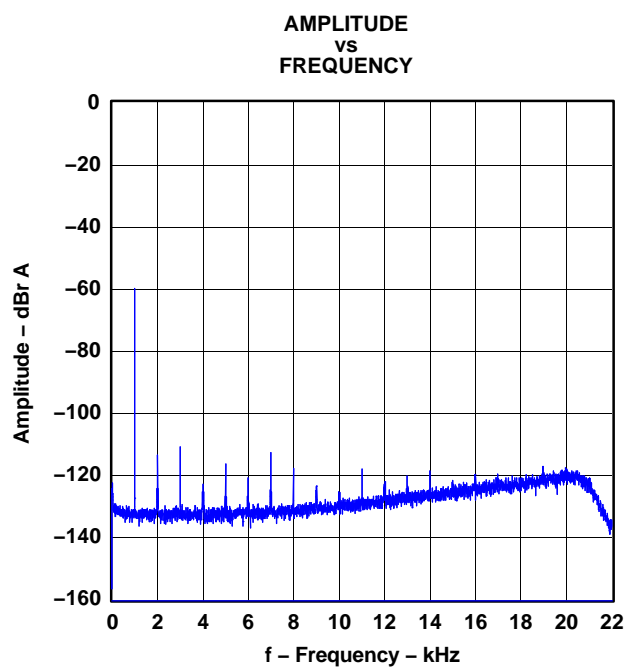


Figure 8.



## THEORY OF OPERATION

### POWER SUPPLIES

This power device requires only two power supply voltages: GVDD\_x and PVDD\_x.

GVDD\_x is the gate drive supply for the device, which is usually supplied from an external 12-V power supply. GVDD\_x is also connected to an internal LDR that regulates the GVDD\_x voltage down to the logic power supply, 3.3 V, for the TAS5121I internal logic blocks. Each GVDD\_x pin is decoupled to system ground by a 1-μF capacitor.

PVDD\_x is the H-bridge power supply. Two power pins are provided for each half-bridge due to the high current density. It is important to follow the circuit and PCB layout recommendations for the design of the PVDD\_x connection. For component suggestions, see the *Typical Application Configuration Used With TAS5026 PWM Processor* section in this document. Following these recommendations is important because they influence key system parameters such as EMI, idle current, and audio performance.

When GVDD\_x is applied, while  $\overline{\text{RESET}}$  is held low, the error latches are cleared,  $\overline{\text{SHUTDOWN}}$  is set high, and the outputs are held in a high-impedance state. The bootstrap (BST) capacitor is charged by the current path through the internal BST diode and external resistors placed on the PCB from each OUT\_x pin to ground.

Ideally, PVDD\_x is applied after GVDD\_x. When GVDD\_x and PVDD\_x are applied, the TAS5121I is ready for operation. PWM input signals can then be applied any time during the power-on sequence, but they must be active and stable before  $\overline{\text{RESET}}$  is set high.

### Recommendations for Powering Up

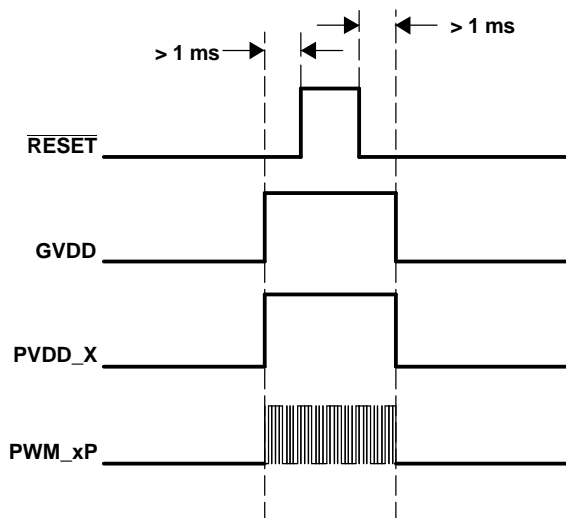


Table 1 describes the input conditions and the output states of the device.

**Table 1. Input/Output States**

| INPUTS                    |        |        |                              | OUTPUTS |       | CONDITION<br>DESCRIPTION |
|---------------------------|--------|--------|------------------------------|---------|-------|--------------------------|
| $\overline{\text{RESET}}$ | PWM_AP | PWM_BP | $\overline{\text{SHUTDOWN}}$ | OUT_A   | OUT_B |                          |
| X                         | X      | X      | 0                            | Hi-Z    | Hi-Z  | Shutdown                 |
| 0                         | X      | X      | 1                            | Hi-Z    | Hi-Z  | Reset                    |
| 1                         | 0      | 0      | 1                            | GND     | GND   |                          |
| 1                         | 0      | 0      | 1                            | PVDD    | PVDD  | Normal                   |
| 1                         | 0      | 1      | 1                            | GND     | PVDD  | Normal                   |
| 1                         | 1      | 1      | 1                            | PVDD    | PVDD  | Reserved                 |

After the previously mentioned conditions are met, the device output begins. If PWM\_AP is equal to a high and PWM\_BP is equal to a low, the high-side MOSFET in the A half-bridge of the output H-bridge conducts while the

## THEORY OF OPERATION (continued)

low-side MOSFET in the A half-bridge is not conducting. Because the source of the high-side MOSFET is referenced to the drain of the low-side MOSFET, a bootstrapped capacitor is used to eliminate the need for additional high-voltage power supplies. Under this condition, the opposite is true for the B half-bridge of the output H-bridge. The low-side MOSFET in the B half-bridge conducts while the high-side MOSFET is not conducting; therefore, the load connected between the OUT\_A and OUT\_B pins has PVDD applied to it from the A side while ground is applied from the B side for the period of time PWM\_AP is high and PWM\_BP is low. Furthermore, when the PWM signals change to the condition where PWM\_AP is low and PWM\_BP is high, the opposite condition exists.

A constant high level is not permitted on the PWM inputs. This condition causes the BST capacitors to discharge and can cause device damage.

A digitally controlled dead-time circuit controls the transitions between the high-side and low-side MOSFETs to ensure that both devices in each half-bridge are not conducting simultaneously.

## POWERING DOWN

For power down of the TAS5121I, an opposite approach is necessary. The  $\overline{\text{RESET}}$  must be asserted LOW before the valid PWM signal is removed.

## PRECAUTION

The TAS5121I must always start up in the high-impedance (Hi-Z) state. In this state, the BST capacitor is precharged by a resistor on each PWM output node to ground. See *Typical Application Configuration Used With TAS5026 PWM Processor*. This ensures that the TAS5121I is ready for receiving PWM pulses, indicating either HIGH- or LOW-side turnon after  $\overline{\text{RESET}}$  is deasserted to the power stage.

With the following pulldown resistor and BST capacitor size, the BST charge time is:

- $C = 33 \text{ nF}$ ,  $R = 4.7 \text{ k}\Omega$
- $R \times C \times 5 = 775.5 \mu\text{s}$

After GVDD has been applied, it takes approximately 800  $\mu\text{s}$  to fully charge the BST capacitor. During this time,  $\overline{\text{RESET}}$  must be kept low. After approximately 1 ms, the power-stage BST is charged and ready.  $\overline{\text{RESET}}$  can now be released if the PWM modulator is ready and is streaming valid PWM signals to the device. Valid PWM signals are switching PWM signals with a frequency between 350-400 kHz. A constant HIGH level on PWM+ forces the high-side MOSFET ON until it eventually runs out of BST capacitor energy. Putting the device in this condition should be avoided.

In practice, this means that the DVDD-to-PWM processor (modulator) should be stable, and initialization should be completed before  $\overline{\text{RESET}}$  is deasserted to the TAS5121I.

## CONTROL I/O

### SHUTDOWN PIN: $\overline{\text{SD}}$

The  $\overline{\text{SD}}$  pin functions as an output pin and is intended for protection-mode signaling to, for example, a controller or other front-end device. The pin is open-drain with an internal pullup to DVDD.

The logic output is, as shown in Table 2, a combination of the device state and  $\overline{\text{RESET}}$  input.

**Table 2. Error Indication**

| $\overline{\text{SD}}$ | $\overline{\text{RESET}}$ | DESCRIPTION  |
|------------------------|---------------------------|--|
| 0                      | 0                         | Reserved   |
| 0                      | 1                         | Device in protection mode, i.e., UVP and/or OC and/or OT error       |
| 1 <sup>(1)</sup>       | 0                         | Device set high-impedance (Hi-Z), $\overline{\text{SD}}$ forced high |
| 1                      | 1                         | Normal operation   |

(1)  $\overline{\text{SD}}$  is independent from  $\overline{\text{RESET}}$ . This is desirable to maintain compatibility with some TI PWM modulators.

## OVERTEMPERATURE WARNING PIN: $\overline{\text{OTW}}$

The  $\overline{\text{OTW}}$  pin gives a temperature warning signal when temperature exceeds the set limit, as shown in Table 3. The pin is of the open-drain type with an internal pullup to DVDD.

**Table 3.  $\overline{\text{OTW}}$  Temperature Indication**

| $\overline{\text{OTW}}$ | DESCRIPTION                            |
|-------------------------|--|
| 0                       | Junction temperature higher than 115°C |
| 1                       | Junction temperature lower than 115°C  |

## OVERALL REPORTING

The  $\overline{\text{SD}}$  pin, together with the  $\overline{\text{OTW}}$  pin, gives chip state information as described in Table 4.

**Table 4. Error Signal Decoding**

| $\overline{\text{OTW}}$ | $\overline{\text{SD}}$ | DESCRIPTION                                  |
|-------------------------|------------------------|--|
| 0                       | 0                      | Overtemperature error (OTE)                  |
| 0                       | 1                      | Overtemperature warning (OTW)                |
| 1                       | 0                      | Overcurrent (OC) or undervoltage (UVP) error |
| 1                       | 1                      | Normal operation, no errors/warnings         |

## CHIP PROTECTION

The TAS5121I protection function is generally implemented in a closed-loop control system with, for example, a system controller. The TAS5121I contains three individual systems protecting the device against fault conditions. All of the error events result in the output stage being set in a high-impedance state (Hi-Z) for maximum protection of the device and connected equipment.

The device can be recovered by toggling  $\overline{\text{RESET}}$  low and then high, after all errors are cleared. It is recommended that if the error persists, the device is held in reset until user intervention clears the error.

## OVERCURRENT (OC) PROTECTION

The device has individual current protection on both high-side and low-side power-stage FETs. The OC protection works only with the demodulation filter present at the output. See *Filter Demodulation Design* in the *Application Information* section of this data sheet for design constraints.

## OVERTEMPERATURE (OT) PROTECTION

A dual-temperature protection system asserts a warning signal when the device junction temperature exceeds 115°C and shuts down the device when the junction temperature exceeds 150°C. The OT protection circuit is shared by both half-bridges.

## UNDERVOLTAGE PROTECTION (UVP)

Undervoltage lockout occurs when GVDD is insufficient for proper device operation. The UV protection system protects the device under fault power-up and power-down situations by shutting the device down. The UV protection circuits are shared by both half-bridges.

## RESET FUNCTION

The reset has two functions:

- Reset the power stage after a latched error event.
- Hard mute—when  $\overline{\text{RESET}}$  is asserted, the power stage stops switching.

In protection modes where the reset input functions as the means to re-enable operation after an error event, the error latch is cleared on the falling edge of  $\overline{\text{RESET}}$ , and normal operation is resumed on the rising edge of  $\overline{\text{RESET}}$ .

## PROTECTION MODE

### LATCHED SHUTDOWN ON ALL ERRORS

In latched shutdown mode, all error situations result in a permanent shutdown (output stage Hi-Z). Re-enabling can be done by toggling the **RESET** pin.

### MODE PINS SELECTION

The protection mode is selected by connecting M1/M2 to DREG or DGND according to Table 5.

**Table 5. Protection Mode Selection**

| M1 | M2 | PROTECTION MODE                |
|----|----|--------------------------------|
| 0  | 0  | Reserved                       |
| 0  | 1  | Latched shutdown on all errors |
| 1  | 0  | Reserved                       |
| 1  | 1  | Reserved                       |

The output configuration mode is selected by connecting the M3 pin to DREG or DGND according to Table 6.

**Table 6. Output Mode Selection**

| M3 | OUTPUT MODE                         |
|----|-------------------------------------|
| 0  | Bridge-tied load output stage (BTL) |
| 1  | Reserved                            |

## APPLICATION INFORMATION

### DEMODULATION FILTER DESIGN

The TAS5121I amplifier outputs are driven by high-current DMOS transistors in an H-bridge configuration. These transistors are either off or fully on.

The result is a square-wave output signal with a duty cycle that is proportional to the amplitude of the audio signal. It is recommended that a second-order LC filter be used to recover the audio signal.

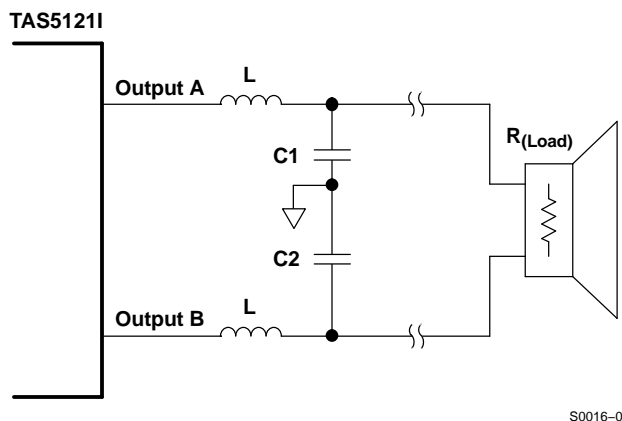


Figure 9. Demodulation Filter

The main purpose of the demodulation filter is to attenuate the high-frequency components of the output signals that are out of the audio band.

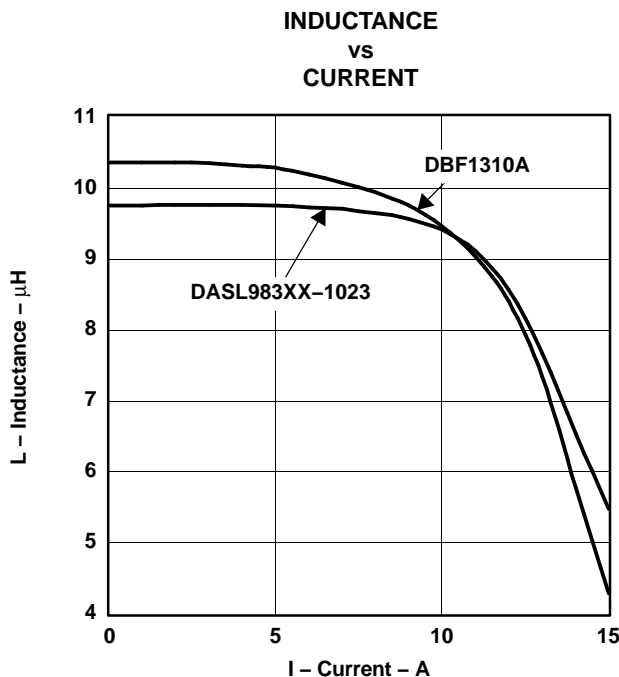
Design of the demodulation filter significantly affects the audio performance of the power amplifier. Therefore, to ensure proper operation of the OC protection circuit and meet the device THD+N specification, the selection of the inductors used in the output filter should be carefully considered. The rule is that the inductance should remain stable within the range of peak current seen at maximum output power and deliver approximately 5  $\mu\text{H}$  of inductance at 15 A.

If this rule is observed, the TAS5121I should not have distortion issues due to the output inductors. This prevents device damage due to overcurrent conditions because of inductor saturation in the output filter.

Another parameter to be considered is the idle current loss in the inductor. This can be measured or specified as inductor dissipation (D). The target specification for dissipation is less than 0.05. If this specification is not met, idle current increases.

In general, 10- $\mu\text{H}$  inductors suffice for most applications. The frequency response of the amplifier is slightly altered by the change in output load resistance; however, unless tight control of frequency response is necessary (better than 0.5 dB), it is not necessary to deviate from 10  $\mu\text{H}$ .

The graphs in Figure 10 display the inductance-versus-current characteristics of two inductors that are suggested for use with the TAS5121I.

**APPLICATION INFORMATION (continued)****Figure 10. Inductance Saturation**

The selection of the capacitors that are placed from the output of each inductor to ground is simple. To complete the output filter, use a 1-μF capacitor with a voltage rating at least twice the voltage applied to the output stage (PVDD\_x).

This capacitor should be a good quality polyester dielectric.

**THERMAL INFORMATION**

The following information is provided as an example.

The thermally enhanced package provided with the TAS5121I is designed to be interfaced directly to a heatsink using a thermal interface compound (for example, Wakefield Engineering type 126 thermal grease.) The heatsink then absorbs heat from the ICs and transfers it to the ambient air. If the heatsink is carefully designed, this process can reach equilibrium and heat can be continually removed from the ICs without device overtemperature shutdown. Because of the efficiency of the TAS5121I, heatsinks are smaller than those required for linear amplifiers of equivalent performance.

$R_{\theta JA}$  is a system thermal resistance from junction to ambient air. As such, it is a system parameter with roughly the following components:

- $R_{\theta JC}$  (the thermal resistance from junction to case, or in this case the metal pad)
- Heatsink compound thermal resistance
- Heatsink thermal resistance

The thermal grease thermal resistance can be calculated from the exposed pad area and the thermal grease manufacturer's area thermal resistance (expressed in °C-in<sup>2</sup>/W). The area thermal resistance of the example thermal grease with a 0.001-inch-thick layer is about 0.054 °C-in<sup>2</sup>/W. The approximate exposed pad area is as follows:

36-pin PSOP3                      0.116 in<sup>2</sup>

Dividing the example thermal grease area resistance by the area of the pad gives the actual resistance through the thermal grease for the device:

## APPLICATION INFORMATION (continued)

36-pin PSOP3      0.47 °C/W

The thermal resistance of thermally conductive pads is generally higher than a thin thermal grease layer. Thermal tape has an even higher thermal resistance and should not be used with this package.

Heatsink thermal resistance is generally predicted by the heatsink vendor, modeled using a continuous flow dynamics (CFD) model, or measured.

Thus, for a single monaural IC, the system  $R_{\theta JA} = R_{\theta JC} + \text{thermal grease resistance} + \text{heatsink resistance}$ .

Table 7 indicates modeled parameters for one TAS5121I IC on a heatsink. The junction temperature is set at 110°C while delivering 70 W RMS into 4-Ω loads with no clipping. It is assumed that the thermal grease is about 0.001 inch thick (this is critical).

**Table 7. Example of Thermal Simulation**

|  | <b>36-PIN PSOP3</b> |
|--|---------------------|
| Ambient temperature                        | 25°C                |
| Power to load                              | 70 W                |
| Delta T inside package                     | 5.5°C               |
| Delta T through thermal grease             | 3.2°C               |
| Required heatsink thermal resistance       | 11.0°C/W            |
| Junction temperature                       | 110°C               |
| System $R_{\theta JA}$                     | 12.3°C/W            |
| $R_{\theta JA} * \text{power dissipation}$ | 85°C                |
| $R_{\theta JC}$                            | 0.85°C/W            |

As an indication of the importance of keeping the thermal grease layer thin, if the thermal grease layer increases to 0.002 inches thick, the required heatsink thermal resistance increases to 5.2°C/W for the PSOP3 package.

## REFERENCES

1. *Digital Audio Measurements* application report – TI ([SLAA114](#))
2. *PowerPAD™ Thermally Enhanced Package* technical brief – TI ([SLMA002](#))
3. *System Design Considerations for True Digital Audio Power Amplifiers* application report – TI ([SLAA117](#))
4. *Voltage Spike Measurement Technique and Specification* application note – TI ([SLEA025](#))

**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TAS5121IDKD      | ACTIVE                | HSSOP        | DKD             | 36   | 29          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-4-260C-72 HR           |
| TAS5121IDKDE4    | ACTIVE                | HSSOP        | DKD             | 36   | 29          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-4-260C-72 HR           |
| TAS5121IDKDR     | ACTIVE                | HSSOP        | DKD             | 36   | 500         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-4-260C-72 HR           |
| TAS5121IDKDRE4   | ACTIVE                | HSSOP        | DKD             | 36   | 500         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-4-260C-72 HR           |

<sup>(1)</sup> 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.

<sup>(2)</sup> 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.

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**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)

<sup>(3)</sup> 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**


\*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 |
|--------------|--------------|-----------------|------|-----|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TAS5121IDKDR | HSSOP        | DKD             | 36   | 500 | 330.0              | 24.4               | 14.7    | 16.4    | 4.0     | 20.0    | 24.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS

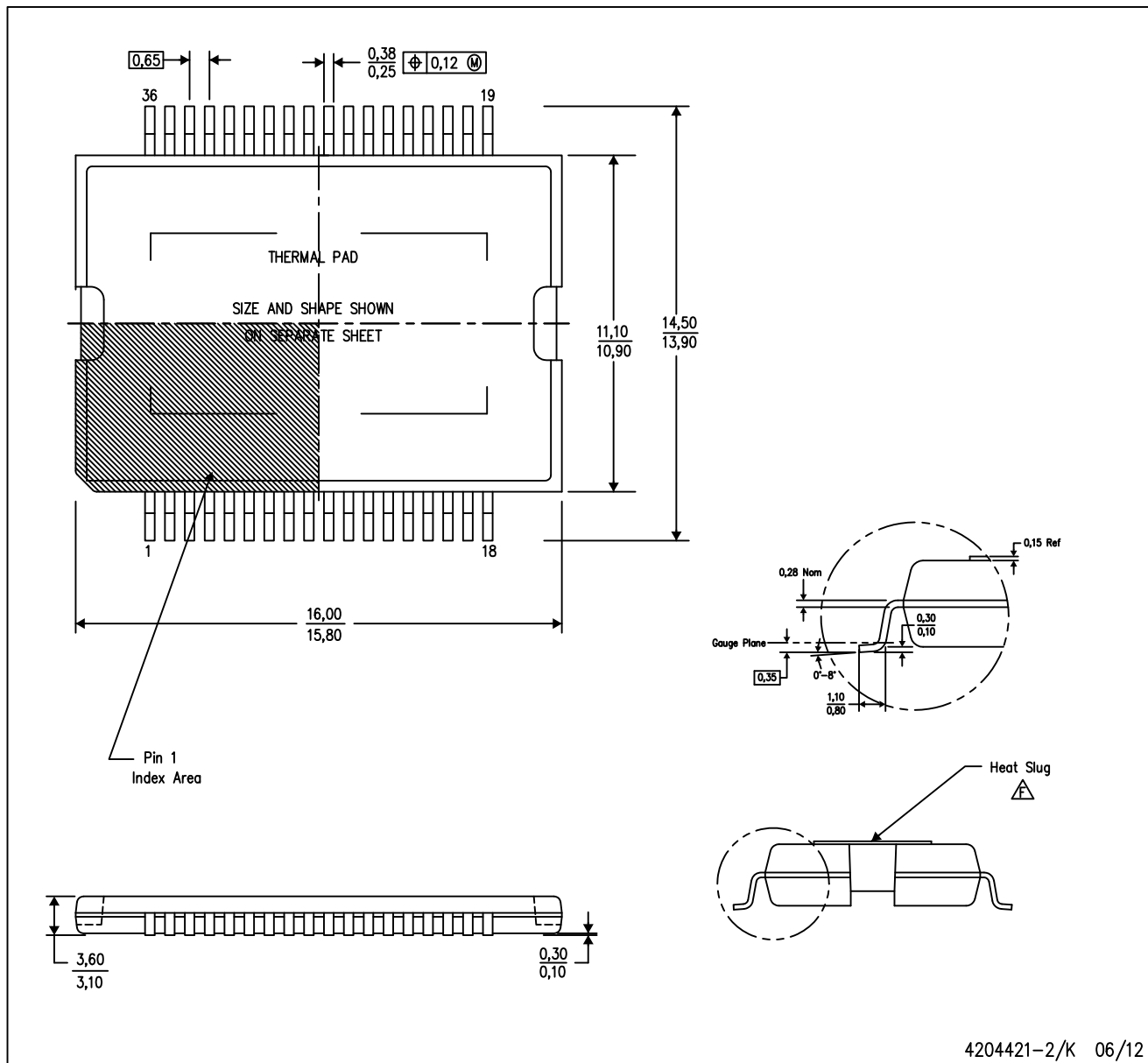


\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|-----|-------------|------------|-------------|
| TAS5121IDKDR | HSSOP        | DKD             | 36   | 500 | 337.0       | 343.0      | 41.0        |

DKD (R-PDSO-G36)

PowerPAD™ PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion not to exceed 0.15mm.
  - This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at [www.ti.com](http://www.ti.com) <<http://www.ti.com>>.
  - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
- △ The package thermal performance is optimized for conductive cooling with attachment to an external heat sink.

PowerPAD is a trademark of Texas Instruments.

## THERMAL PAD MECHANICAL DATA

DKD (R-PDSO-G36)

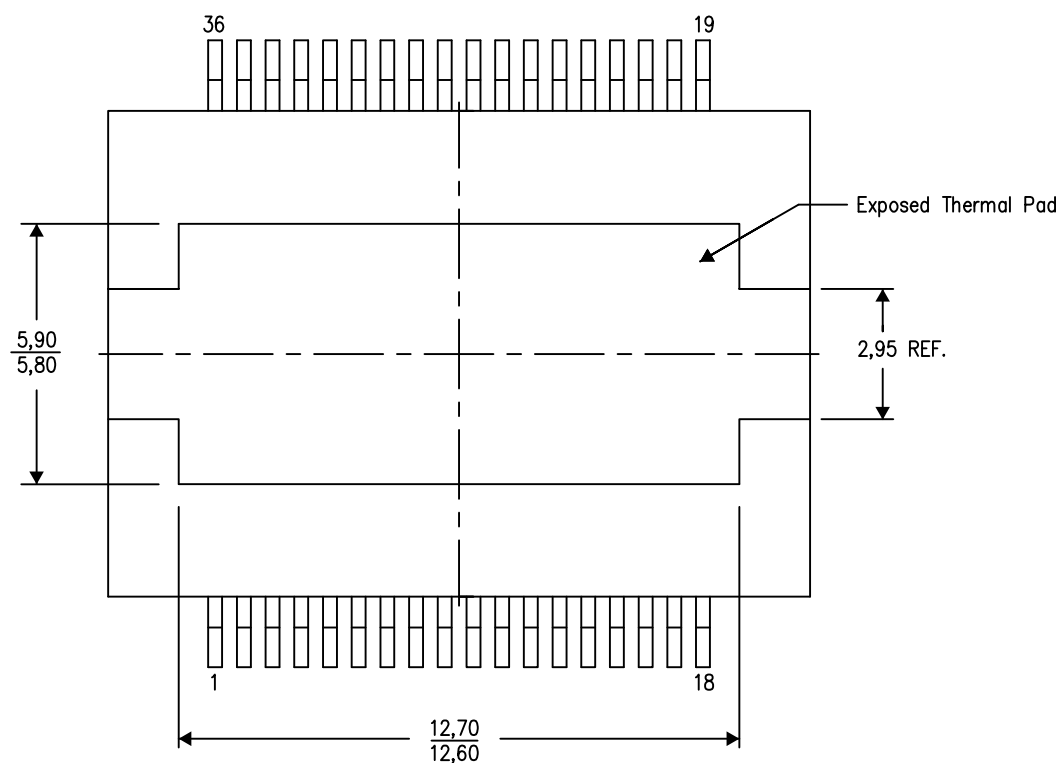
PowerPAD™ PLASTIC SMALL OUTLINE

### THERMAL INFORMATION

This PowerPAD™ package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. This design optimizes the heat transfer from the integrated circuit (IC).

For additional information on the PowerPAD package and how to take advantage of its heat dissipating abilities, refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 and Application Brief, PowerPAD Made Easy, Texas Instruments Literature No. SLMA004. Both documents are available at [www.ti.com](http://www.ti.com).

The exposed thermal pad dimensions for this package are shown in the following illustration.



Top View

Top View

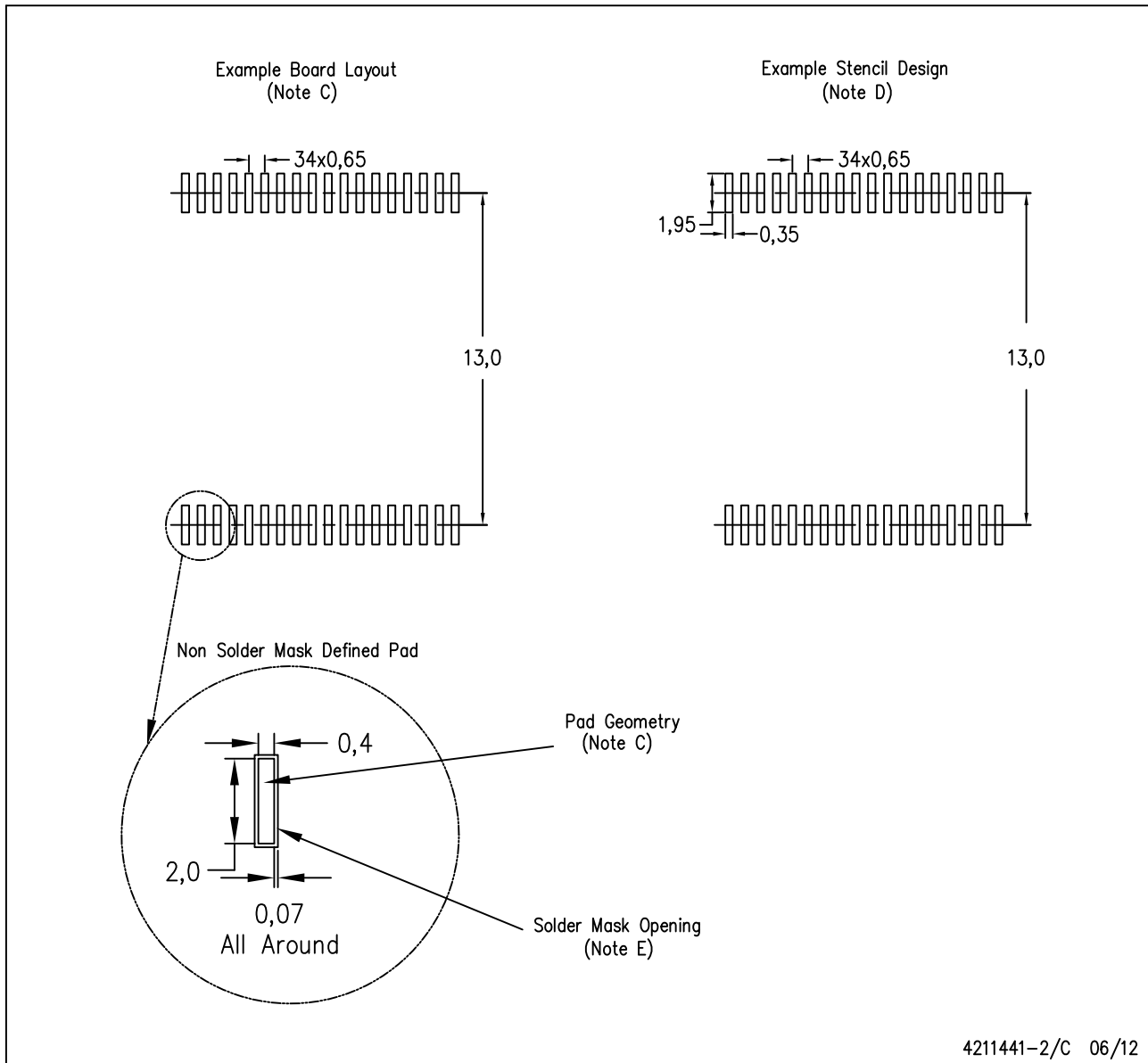
Exposed Thermal Pad Dimensions

4210894-2/E 06/12

NOTE: All linear dimensions are in millimeters

DKD (R-PDSO-G36)

PowerPAD™ PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. 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.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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