The TPA152 is a stereo audio power amplifier capable of less than 0.1% THD+N at 1 kHz when delivering 75 mW per channel into a 32-Ω load. THD+N is less than 0.2% across the audio band of 20 to 20 kHz. For 10 kΩ loads, the THD+N performance is better than 0.005% at 1 kHz, and less than 0.01% across the audio band of 20 to 20 kHz.

The TPA152 is ideal for use as an output buffer for the audio CODEC in PC systems. It is also excellent for use where a high-performance head phone/line-out amplifier is needed. Depop circuitry is integrated to reduce transients during power up, power down, and mute mode.

Amplifier gain is externally configured by means of two resistors per input channel and does not require external compensation for settings of 1 to 10. The TPA152 is packaged in the 8-pin SOIC (D) package that reduces board space and facilitates automated assembly.
### Available Options

<table>
<thead>
<tr>
<th>$T_A$</th>
<th>Packaged Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>−40°C to 85°C</td>
<td>TPA152DT</td>
</tr>
</tbody>
</table>

† The D packages are available taped and reeled. To order a taped and reeled part, add the suffix R (e.g., TPA152DR)

### Terminal Functions

<table>
<thead>
<tr>
<th>Terminal Name</th>
<th>No.</th>
<th>I/O</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYPASS</td>
<td>3</td>
<td>I/O</td>
<td>BYPASS is the tap to the voltage divider for internal mid-supply bias. This terminal should be connected to a 0.1-$\mu$F to 1-$\mu$F capacitor.</td>
</tr>
<tr>
<td>GND</td>
<td>7</td>
<td>I/O</td>
<td>GND is the ground connection.</td>
</tr>
<tr>
<td>IN1–</td>
<td>8</td>
<td>I</td>
<td>IN1– is the inverting input for channel 1.</td>
</tr>
<tr>
<td>IN2–</td>
<td>4</td>
<td>I</td>
<td>IN2– is the inverting input for channel 2.</td>
</tr>
<tr>
<td>MUTE</td>
<td>2</td>
<td>I</td>
<td>A logic high puts the device into MUTE mode.</td>
</tr>
<tr>
<td>VDD</td>
<td>6</td>
<td>I/O</td>
<td>VDD is the supply voltage terminal.</td>
</tr>
<tr>
<td>VO1</td>
<td>1</td>
<td>O</td>
<td>VO1 is the audio output for channel 1.</td>
</tr>
<tr>
<td>VO2</td>
<td>5</td>
<td>O</td>
<td>VO2 is the audio output for channel 1.</td>
</tr>
</tbody>
</table>
absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage, V_DD</td>
<td>4.5</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Input voltage, V_I</td>
<td>–0.3 V to V_DD + 0.3 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous total power dissipation</td>
<td>–0.3 V to V_DD + 0.3 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating junction temperature range, T_J</td>
<td>–40°C to 150°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating case temperature range, T_C</td>
<td>–40°C to 125°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature range, T_stg</td>
<td>–65°C to 150°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds</td>
<td>260°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

† 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.

DISSIPATION RATING TABLE

<table>
<thead>
<tr>
<th>PACKAGE</th>
<th>T_A ≤ 25°C</th>
<th>DERATING FACTOR</th>
<th>T_A = 70°C</th>
<th>T_A = 85°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>724 mW</td>
<td>5.8 mW/°C</td>
<td>464 mW</td>
<td>376 mW</td>
</tr>
</tbody>
</table>

recommended operating conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage, V_DD</td>
<td>4.5</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Operating free-air temperature, T_A</td>
<td>–40</td>
<td>85</td>
<td>°C</td>
</tr>
</tbody>
</table>

dc electrical characteristics at T_A = 25°C, V_DD = 5 V

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>V ОО</td>
<td>Output offset voltage</td>
<td>10</td>
<td>mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply ripple rejection ratio</td>
<td>V_DD = 4.9 V to 5.1 V</td>
<td>81</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IDD</td>
<td>Supply current</td>
<td>5.5</td>
<td>14</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>IDD(MUTE)</td>
<td>Supply current in MUTE</td>
<td>5.5</td>
<td>14</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Z_I</td>
<td>Input impedance</td>
<td>&gt;1</td>
<td>MΩ</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ac operating characteristics V_DD = 5 V, T_A = 25°C, R_L = 32 Ω (unless otherwise noted)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>P_O</td>
<td>Output power (each channel)</td>
<td>THD ≤ 0.03%, Gain = 1, See Figure 1</td>
<td>75†</td>
<td>mW</td>
<td></td>
</tr>
<tr>
<td>THD+N</td>
<td>Total harmonic distortion plus noise</td>
<td>P_O = 75 mW, 20 Hz–20 kHz, Gain = 1, See Figure 2</td>
<td>0.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B_OM</td>
<td>Maximum output power bandwidth</td>
<td>A_V = 5, THD &lt;0.6%, See Figure 2</td>
<td>&gt;20</td>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td>Phase margin</td>
<td>Open loop, See Figure 16</td>
<td>80°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply ripple rejection ratio</td>
<td>1 kHz, C_B = 1 μF, See Figure 12</td>
<td>65</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mute attenuation</td>
<td>See Figure 15</td>
<td>110</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ch/Ch output separation</td>
<td>See Figure 13</td>
<td>102</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal-to-Noise ratio</td>
<td>V_O = 1 V_{rms}, Gain = 1, See Figure 11</td>
<td>104</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V_N</td>
<td>Noise output voltage</td>
<td>See Figure 10</td>
<td>6</td>
<td>μV_{rms}</td>
<td></td>
</tr>
</tbody>
</table>

† Measured at 1 kHz.

NOTES: 1. The dc output voltage is approximately V_DD/2.
2. Output power is measured at the output pins of the IC at 1 kHz.
TYPICAL CHARACTERISTICS

Table of Graphs

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>FIGURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>THD+N</td>
<td>Total harmonic distortion plus noise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_i = 1 \ V_{(rms)}$, $V_o(PP) = 4 \ V$,</td>
<td>1, 4</td>
</tr>
<tr>
<td></td>
<td>$20 \ Hz$–$20 \ kHz$, Gain = 1, See Figure 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$20 \ Hz$–$20 \ kHz$, Gain = 1, See Figure 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$0.005%$</td>
<td></td>
</tr>
<tr>
<td>BOM</td>
<td>Maximum output power bandwidth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$G = 5$, THD &lt;0.02%, See Figure 6</td>
<td>&gt;20 kHz</td>
</tr>
<tr>
<td>kSVR</td>
<td>Supply voltage rejection ratio</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$1 \ kHz$, $C_B = 1 \ \mu F$, See Figure 12</td>
<td>65 dB</td>
</tr>
<tr>
<td></td>
<td>$80^\circ$</td>
<td></td>
</tr>
<tr>
<td>SNR</td>
<td>Signal-to-noise ratio</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_o = 1 \ V_{(rms)}$, Gain = 1, See Figure 11</td>
<td>104 dB</td>
</tr>
<tr>
<td>Vn</td>
<td>Noise output voltage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$6 \ \mu V_{(rms)}$</td>
<td></td>
</tr>
<tr>
<td>IDD</td>
<td>Supply current</td>
<td></td>
</tr>
<tr>
<td></td>
<td>vs Supply voltage</td>
<td>19</td>
</tr>
<tr>
<td>PO</td>
<td>Output power</td>
<td></td>
</tr>
<tr>
<td></td>
<td>vs Load resistance</td>
<td>20</td>
</tr>
<tr>
<td>PD</td>
<td>Power dissipation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>vs Output power</td>
<td>21</td>
</tr>
</tbody>
</table>

† Measured at 1 kHz.
TYPICAL CHARACTERISTICS

TOTAL HARMONIC DISTORTION PLUS NOISE vs OUTPUT POWER

Figure 1

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

Figure 2

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

Figure 3

TOTAL HARMONIC DISTORTION PLUS NOISE vs OUTPUT POWER

Figure 4
TYPICAL CHARACTERISTICS

TOTAL HARMONIC DISTORTION PLUS NOISE vs OUTPUT VOLTAGE

- **Figure 5**
  - THD+N – Total Harmonic Distortion + Noise – %
  - VO – Output Voltage – V (rms)
  - f = 1 kHz
  - AV = –1 V/V
  - RL = 10 kΩ

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

- **Figure 6**
  - THD+N – Total Harmonic Distortion + Noise – %
  - f – Frequency – Hz
  - VO = 1 V (rms)
  - RL = 10 kΩ
  - AV = –5 V/V
  - AV = –2 V/V
  - AV = –1 V/V

TOTAL HARMONIC DISTORTION PLUS NOISE vs OUTPUT VOLTAGE

- **Figure 7**
  - THD+N – Total Harmonic Distortion + Noise – %
  - VO – Output Voltage – V (rms)
  - f = 1 kHz
  - f = 20 kHz
  - f = 20 Hz
  - AV = –1 V/V
  - RL = 10 kΩ

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

- **Figure 8**
  - THD+N – Total Harmonic Distortion + Noise – %
  - f – Frequency – Hz
  - VO(PP) = 4 V
  - AV = –1 V/V
  - RL = 10 kΩ
**TYPICAL CHARACTERISTICS**

**Figure 9**

**TOTAL HARMONIC DISTORTION PLUS NOISE**

VS

FREQUENCY

\[ \text{THD+N} = \text{Total Harmonic Distortion + Noise} \%

\]

- \( V_I = 1 \text{ V (rms)} \)
- \( A_V = -1 \text{ V/V} \)
- \( R_L = 32 \Omega \)
- \( R_L = 10, 47, \text{ and } 100 \text{ k}\Omega \)

**Figure 10**

**OUTPUT NOISE VOLTAGE**

VS

FREQUENCY

\[ V_n = \text{Output Noise Voltage} \mu\text{V} \]

- \( V_{DD} = 5 \text{ V} \)
- \( BW = 10 \text{ Hz to } 22 \text{ kHz} \)
- \( R_L = 32 \Omega \) to \( 10 \text{ k}\Omega \)
- \( A_V = -1 \text{ V/V} \)

**Figure 11**

**SIGNAL-TO-NOISE RATIO**

VS

GAIN

\[ \text{SNR} = \text{Signal-to-Noise Ratio} \text{ dB} \]

- \( R_I = 20 \text{ k}\Omega \)
- \( R_L = 10 \text{ k}\Omega \)
- \( R_L = 32 \Omega \)

**Figure 12**

**SUPPLY RIPPLE REJECTION RATIO**

VS

FREQUENCY

\[ \text{Supply Ripple Rejection Ratio} \text{ dB} \]

- \( V_{DD} = 5 \text{ V} \)
- \( R_L = 32 \Omega \) to \( 10 \text{ k}\Omega \)
- \( C_B = 0.1 \mu\text{F} \)
- \( C_B = 1 \mu\text{F} \)
- \( C_B = 2.5 \text{ V} \)
TYPICAL CHARACTERISTICS

**CROSSTALK vs FREQUENCY**

![Crosstalk vs Frequency Graph](image)

- **Figure 13**
  - $P_O = 75 \text{ mW}$
  - $V_{DD} = 5 \text{ V}$
  - $R_L = 32 \Omega$
  - $C_B = 1 \mu F$
  - $A_V = -1 \text{ V/V}$
  - Right to Left
  - Left to Right

- **Figure 14**
  - $V_O = 1 \text{ V}$
  - $V_{DD} = 5 \text{ V}$
  - $R_L = 10 \text{ k}\Omega$
  - $C_B = 1 \mu F$
  - $A_V = -1 \text{ V/V}$
  - Right to Left
  - Left to Right

**MUTE ATTENUATION vs FREQUENCY**

![Mute Attenuation vs Frequency Graph](image)

- **Figure 15**
  - $V_{DD} = 5 \text{ V}$
  - $R_L = 32 \Omega$
  - $C_B = 1 \mu F$
TYPICAL CHARACTERISTICS

OPEN-LOOP GAIN AND PHASE

VERSUS FREQUENCY

CLOSED-LOOP GAIN AND PHASE

VERSUS FREQUENCY

Figure 16

Figure 17
TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE

vs

FREQUENCY

Figure 18

SUPPLY CURRENT

vs

SUPPLY VOLTAGE

Figure 19

OUTPUT POWER

vs

LOAD RESISTANCE

Figure 20
TPA152
75-mW STEREO AUDIO POWER AMPLIFIER


TYPICAL CHARACTERISTICS

POWER DISSIPATION VS OUTPUT POWER

Figure 21

APPLICATION INFORMATION

selection of components

Figure 22 is a schematic diagram of a typical application circuit.

Figure 22. TPA152 Typical Application Circuit

† These resistors are optional. Adding these resistors improves the depop performance of the TPA152.
APPLICATION INFORMATION

gain setting resistors, $R_F$ and $R_I$

The gain for the TPA152 is set by resistors $R_F$ and $R_I$ according to equation 1.

\[
\text{Gain} = -\left(\frac{R_F}{R_I}\right)
\]

Given that the TPA152 is a MOS amplifier, the input impedance is very high, consequently input leakage currents are not generally a concern although noise in the circuit increases as the value of $R_F$ increases. In addition, a certain range of $R_F$ values are required for proper start-up operation of the amplifier. Taken together it is recommended that the effective impedance seen by the inverting node of the amplifier be set between 5 kΩ and 20 kΩ. The effective impedance is calculated in equation 2.

\[
\text{Effective Impedance} = \frac{R_FR_I}{R_F + R_I}
\]

As an example, consider an input resistance of 20 kΩ and a feedback resistor of 20 kΩ. The gain of the amplifier would be –1 and the effective impedance at the inverting terminal would be 10 kΩ, which is within the recommended range.

For high performance applications, metal film resistors are recommended because they tend to have lower noise levels than carbon resistors. For values of $R_F$ above 50 kΩ, the amplifier tends to become unstable due to a pole formed from $R_F$ and the inherent input capacitance of the MOS input structure. For this reason, a small compensation capacitor of approximately 5 pF should be placed in parallel with $R_F$. This, in effect, creates a low-pass filter network with the cutoff frequency defined in equation 3.

\[
f_{c(\text{lowpass})} = \frac{1}{2\pi R_FC_F}
\]

For example if $R_F$ is 100 kΩ and $C_F$ is 5 pF then $f_{c(\text{lowpass})}$ is 318 kHz, which is well outside the audio range.

input capacitor, $C_I$

In the typical application, an input capacitor, $C_I$, is required to allow the amplifier to bias the input signal to the proper dc level for optimum operation. In this case, $C_I$ and $R_I$ form a high-pass filter with the corner frequency determined in equation 4.

\[
f_{c(\text{highpass})} = \frac{1}{2\pi R_IC_I}
\]

The value of $C_I$ is important to consider as it directly affects the bass (low frequency) performance of the circuit. Consider the example where $R_I$ is 20 kΩ and the specification calls for a flat bass response down to 20 Hz. Equation 4 is reconfigured as equation 5.

\[
C_I = \frac{1}{2\pi f_{c(\text{highpass})} R_I}
\]

In this example, $C_I$ is 0.40 μF, so one would likely choose a value in the range of 0.47 μF to 1 μF. A further consideration for this capacitor is the leakage path from the input source through the input network ($R_I$, $C_I$) and the feedback resistor ($R_F$) to the load. This leakage current creates a dc offset voltage at the input to the amplifier that reduces useful headroom, especially in high-gain applications (> 10). For this reason a low-leakage tantalum or ceramic capacitor is the best choice. When polarized capacitors are used, the positive side of the capacitor should face the amplifier input in most applications, as the dc level there is held at $V_{DD}/2$, which is likely higher than the source dc level. Please note that it is important to confirm the capacitor polarity in the application.
APPLICATION INFORMATION

**power supply decoupling, C_S**

The TPA152 is a high-performance CMOS audio amplifier that requires adequate power supply decoupling to ensure that the output total harmonic distortion (THD) is as low as possible. Power supply decoupling also prevents oscillations for long lead lengths between the amplifier and the speaker. The optimum decoupling is achieved by using two capacitors of different types that target different types of noise on the power supply leads. For higher frequency transients, spikes, or digital hash on the line, a good low equivalent-series-resistance (ESR) ceramic capacitor, typically 0.1 µF, placed as close as possible to the device V_DD lead, works best. For filtering lower-frequency noise signals, a larger aluminum electrolytic capacitor of 10 µF or greater placed near the power amplifier is recommended.

**midrail bypass capacitor, C_B**

The midrail bypass capacitor, C_B, serves several important functions. During startup or recovery from shutdown mode, C_B determines the rate at which the amplifier starts up. This helps to push the start-up pop noise into the subaudible range (so slow it can not be heard). The second function is to reduce noise produced by the power supply caused by coupling into the output drive signal. This noise is from the midrail generation circuit internal to the amplifier. The capacitor is fed from a 160-kΩ source inside the amplifier. To keep the start-up pop as low as possible, the relationship shown in equation 6 should be maintained.

\[
\frac{1}{C_B \times 160 \, k\Omega} \leq \frac{1}{(C_I R_I)}
\]  

(6)

As an example, consider a circuit where C_B is 1 µF, C_I is 1 µF and R_I is 20 kΩ. Inserting these values into the equation 9 results in:

\[
6.25 \leq 50
\]

which satisfies the rule. Bypass capacitor, C_B, values of 0.1 µF to 1 µF ceramic or tantalum low-ESR capacitors are recommended for the best THD and noise performance.

**output coupling capacitor, C_C**

In the typical single-supply single-ended (SE) configuration, an output coupling capacitor (C_C) is required to block the dc bias at the output of the amplifier thus preventing dc currents in the load. As with the input coupling capacitor, the output coupling capacitor and impedance of the load form a high-pass filter governed by equation 7.

\[
f_{C(high)} = \frac{1}{2\pi R_L C_C}
\]  

(7)

The main disadvantage, from a performance standpoint, is that the load impedances are typically small, which drive the low-frequency corner higher. Large values of C_C are required to pass low frequencies into the load. Consider the example where a C_C of 68 µF is chosen and loads vary from 32 Ω to 47 kΩ. Table 1 summarizes the frequency response characteristics of each configuration.
APPLICATION INFORMATION

Table 1. Common Load Impedances vs Low Frequency Output Characteristics in SE Mode

<table>
<thead>
<tr>
<th>R_L</th>
<th>C_C</th>
<th>LOWEST FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 Ω</td>
<td>68 μF</td>
<td>73 Hz</td>
</tr>
<tr>
<td>10,000 Ω</td>
<td>68 μF</td>
<td>0.23 Hz</td>
</tr>
<tr>
<td>47,000 Ω</td>
<td>68 μF</td>
<td>0.05 Hz</td>
</tr>
</tbody>
</table>

As Table 1 indicates, headphone response is adequate and drive into line level inputs (a home stereo for example) is very good.

The output coupling capacitor required in single-supply SE mode also places additional constraints on the selection of other components in the amplifier circuit. With the rules described earlier still valid, add the following relationship:

\[
\frac{1}{C_B \times 160 \, \text{kΩ}} \leq \frac{1}{(C_I R_I)} \leq \frac{1}{R_L C_C}
\]  

output pull-down resistor, R_C + R_O

Placing a 100-Ω resistor, R_C, from the output side of the coupling capacitor to ground insures the coupling capacitor, C_C, is charged before a plug is inserted into the jack. Without this resistor, the coupling capacitor would charge rapidly upon insertion of a plug, leading to an audible pop in the headphones.

Placing a 20-kΩ resistor, R_O, from the output of the IC to ground insures that the coupling capacitor fully discharges at power down. If the supply is rapidly cycled without this capacitor, a small pop may be audible in 10-kΩ loads.

using low-ESR capacitors

Low-ESR capacitors are recommended throughout this applications section. A real capacitor can be modeled simply as a resistor in series with an ideal capacitor. The voltage drop across this resistor minimizes the beneficial effects of the capacitor in the circuit. The lower the equivalent value of this resistance, the more the real capacitor behaves like an ideal capacitor.
## PACKAGING INFORMATION

<table>
<thead>
<tr>
<th>Orderable Device</th>
<th>Status (1)</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>Package Qty</th>
<th>Eco Plan (2)</th>
<th>Lead finish/Ball material (6)</th>
<th>MSL Peak Temp (3)</th>
<th>Op Temp (°C)</th>
<th>Device Marking (4/5)</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPA152D</td>
<td>ACTIVE</td>
<td>SOIC</td>
<td>D</td>
<td>8</td>
<td>75</td>
<td>RoHS &amp; Green</td>
<td>NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 85</td>
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<td>-40 to 85</td>
<td>TPA152</td>
<td>Samples</td>
</tr>
</tbody>
</table>

(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. 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) **RoHS**: TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
- **RoHS Exempt**: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
- **Green**: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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### TAPE AND REEL INFORMATION

<table>
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<th>Device</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>SPQ</th>
<th>Reel Diameter (mm)</th>
<th>Reel Width (W1) (mm)</th>
<th>A0 (mm)</th>
<th>B0 (mm)</th>
<th>K0 (mm)</th>
<th>P1 (mm)</th>
<th>W (mm)</th>
<th>Pin 1 Quadrant</th>
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</table>

*All dimensions are nominal.*

**Definitions:**
- **A0**: Dimension designed to accommodate the component width
- **B0**: Dimension designed to accommodate the component length
- **K0**: Dimension designed to accommodate the component thickness
- **W**: Overall width of the carrier tape
- **P1**: Pitch between successive cavity centers

**TAPE DIMENSIONS**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**

- **Pocket Quadrants**
- **Sprocket Holes**
- **User Direction of Feed**
### TAPE AND REEL BOX DIMENSIONS

*All dimensions are nominal*

<table>
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<th>SPQ</th>
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