1 Features
- Ultra-small X2SON package (0.8 mm × 0.8 mm × 0.4 mm)
- Tiny 5-pin SOT-23, SC70, and VSSOP packages
- Wide supply voltage range of 1.6 V to 6.5 V
- Quiescent supply current of 315 nA
- Low propagation delay of 3 µs
- Rail-to-rail common-mode input voltage
- Internal hysteresis
- Push-pull output (TLV703x)
- Open-drain output (TLV704x)
- No phase reversal for overdriven inputs
- –40°C to 125°C Operating temperature

2 Applications
- Mobile phones and tablets
- Portable and battery-powered devices
- IR receivers
- Level translators
- Threshold detectors and discriminators
- Window comparators
- Rotary position encoders
- Zero-crossing detectors

3 Description
The TLV7031/TLV7041 (single-channel) and TLV7032/42 (dual-channel) are low-voltage, nanoPower comparators. These devices are available in an ultra-small, leadless package measuring 0.8 mm × 0.8 mm as well as standard 5-pin SC70 and SOT-23 packages, making them applicable for space-critical designs like smartphones, smart meters, and other portable or battery-powered applications.

The TLV703x and TLV704x offer an excellent combination of speed and power, with a propagation delay of 3 µs and a quiescent supply current of 315 nA. The benefit of fast response time at nanoPower enables power-conscious systems to monitor and respond quickly to fault conditions. With an operating voltage range of 1.6 V to 6.5 V, these comparators are compatible with 3-V and 5-V systems.

The TLV703x and TLV704x also ensure no output phase inversion with overdriven inputs and internal hysteresis, so engineers can use this family of comparators for precision voltage monitoring in harsh, noisy environments where slow-moving input signals must be converted into clean digital outputs.

The TLV703x has a push-pull output stage capable of sinking and sourcing milliamps of current when controlling an LED or driving a capacitive load. The TLV704x has an open-drain output stage that can be pulled beyond V_{CC}, making it appropriate for level translators and bipolar to single-ended converters.

Device Information

<table>
<thead>
<tr>
<th>PART NUMBERS</th>
<th>PACKAGE (PINS)</th>
<th>BODY SIZE (NOM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLV7031, TLV7041</td>
<td>X2SON (5)</td>
<td>0.80 mm × 0.80 mm</td>
</tr>
<tr>
<td></td>
<td>SC70 (5)</td>
<td>2.00 mm × 1.25 mm</td>
</tr>
<tr>
<td></td>
<td>SOT-23 (5)</td>
<td>2.90 mm × 1.60 mm</td>
</tr>
<tr>
<td>TLV7032, TLV7042</td>
<td>VSSOP (8)</td>
<td>3.00 mm × 3.00 mm</td>
</tr>
</tbody>
</table>

(1) For all available packages, see the orderable addendum at the end of the data sheet.

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.
• Specified which device has push-pull output and open-drain output options in Features .......................................................... 1
• Removed (TLV7031) from key graphic title because the graph covers both the TLV7031 and TLV7041 devices ...................... 1
• Added X2SON tabnote to Pin Functions table ............................................................................................................................. 4
• Changed Figure 2 ............................................................................................................................................................................ 10
• Added note to the Timing Diagrams section .............................................................................................................................. 10
• Smoothed Propagation Delay plots in Figure 31 through ........................................................................................................ 11
• Changed vertical labels on Figure 20, Figure 21, Figure 17, and Figure 30 ............................................................................... 13
• Changed Functional Block Diagram ........................................................................................................................................ 16
• Changed text ‘the TLV7041 features an open-drain output stage enabling the output logic levels to be pulled up to an external source up to 7 V’ to ‘the TLV7041 features an open-drain output stage enabling the output logic levels to be pulled up to an external source up to 6.5 V’ ........................................ 17
• Changed Figure 36 .......................................................................................................................................................................... 20
• Added note to the Layout Example section ............................................................................................................................... 27
• Added Documentation Support section ......................................................................................................................................... 28
5 Pin Configuration and Functions

DPW Package
5-Pin X2SON
Top View

DBV and DCK Package
5-Pin SOT-23 and SC70
Top View

<table>
<thead>
<tr>
<th>PIN</th>
<th>I/O(1)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>X2SON(2)</td>
<td>SOT-23, SC70</td>
<td>NAME</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>OUT</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>VCC</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>VEE</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>IN–</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>IN+</td>
</tr>
</tbody>
</table>

(1) I = Input, O = Output, P = Power
(2) The application report Designing and Manufacturing With TI’s X2SON Packages (SCEA055) provides more details on the optimal PCB designs.
## Pin Functions: TLV7032/42

<table>
<thead>
<tr>
<th>PIN NAME</th>
<th>I/O</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>INA–</td>
<td>2</td>
<td>I Inverting input, channel A</td>
</tr>
<tr>
<td>INA+</td>
<td>3</td>
<td>I Noninverting input, channel A</td>
</tr>
<tr>
<td>INB–</td>
<td>6</td>
<td>I Inverting input, channel B</td>
</tr>
<tr>
<td>INB+</td>
<td>5</td>
<td>I Noninverting input, channel B</td>
</tr>
<tr>
<td>OUTA</td>
<td>1</td>
<td>O Output, channel A</td>
</tr>
<tr>
<td>OUTB</td>
<td>7</td>
<td>O Output, channel B</td>
</tr>
<tr>
<td>VEE</td>
<td>4</td>
<td>— Negative (lowest) supply or ground (for single-supply operation)</td>
</tr>
<tr>
<td>VCC</td>
<td>8</td>
<td>— Positive (highest) supply</td>
</tr>
</tbody>
</table>
6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

<table>
<thead>
<tr>
<th>Description</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage ( V_S = V_{CC} - V_{EE} )</td>
<td>–0.3</td>
<td>7</td>
<td>V</td>
</tr>
<tr>
<td>Input pins ((IN+, IN^-))(2)</td>
<td>( V_{EE} - 0.3 )</td>
<td>±10</td>
<td>mA</td>
</tr>
<tr>
<td>Current into Input pins ((IN+, IN^-))</td>
<td>–0.3</td>
<td>( V_{CC} + 0.3 )</td>
<td>V</td>
</tr>
<tr>
<td>Output (OUT) (TLV703x)(3)</td>
<td>( V_{EE} - 0.3 )</td>
<td>7</td>
<td>V</td>
</tr>
<tr>
<td>Output (OUT) (TLV704x)</td>
<td>–65</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>Junction temperature, ( T_J )</td>
<td>150</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) Input terminals are diode-clamped to \( V_{EE} \). Input signals that can swing 0.3V below \( V_{EE} \) must be current-limited to 10mA or less.

(3) Output maximum is \((V_{CC} + 0.3 \text{ V})\) or 7 V, whichever is less.

(4) Short-circuit to ground, one comparator per package.

6.2 ESD Ratings

<table>
<thead>
<tr>
<th>Description</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{ESD} ) Electrostatic discharge</td>
<td>±2000</td>
<td>V</td>
</tr>
<tr>
<td>Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)</td>
<td>±2000</td>
<td>V</td>
</tr>
<tr>
<td>Charged-device model (CDM), per JEDEC specification JESD22-C101(2)</td>
<td>±1000</td>
<td>V</td>
</tr>
</tbody>
</table>

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

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

<table>
<thead>
<tr>
<th>Description</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage ( V_S = V_{CC} - V_{EE} )</td>
<td>1.6</td>
<td>6.5</td>
<td>V</td>
</tr>
<tr>
<td>Input voltage range</td>
<td>( V_{EE} - 0.1 )</td>
<td>( V_{CC} + 0.1 )</td>
<td>V</td>
</tr>
<tr>
<td>Ambient temperature, ( T_A )</td>
<td>–40</td>
<td>125</td>
<td>°C</td>
</tr>
</tbody>
</table>

6.4 Thermal Information (Dual)

<table>
<thead>
<tr>
<th>THERMAL METRIC(1)</th>
<th>TLV7032/TLV7042</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R_{JA} ) Junction-to-ambient thermal resistance</td>
<td>211.7</td>
<td>°C/W</td>
</tr>
<tr>
<td>( R_{JUC(top)} ) Junction-to-case (top) thermal resistance</td>
<td>96.1</td>
<td>°C/W</td>
</tr>
<tr>
<td>( R_{JUB} ) Junction-to-board thermal resistance</td>
<td>133.5</td>
<td>°C/W</td>
</tr>
<tr>
<td>( \Psi_{JT} ) Junction-to-top characterization parameter</td>
<td>28.3</td>
<td>°C/W</td>
</tr>
<tr>
<td>( \Psi_{JB} ) Junction-to-board characterization parameter</td>
<td>131.7</td>
<td>°C/W</td>
</tr>
<tr>
<td>( R_{JUC(bot)} ) Junction-to-case (bottom) thermal resistance</td>
<td>N/A</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.
### 6.5 Thermal Information (Single)

<table>
<thead>
<tr>
<th>THERMAL METRIC(1)</th>
<th>TLV7031/TLV7041</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DPW (X2SON)</td>
</tr>
<tr>
<td></td>
<td>5 PINS</td>
</tr>
<tr>
<td>R(_{JA})</td>
<td>533.2°C/W</td>
</tr>
<tr>
<td>R(_{JC(top)})</td>
<td>302.7°C/W</td>
</tr>
<tr>
<td>R(_{JB})</td>
<td>408.3°C/W</td>
</tr>
<tr>
<td>(\Psi_{JT})</td>
<td>71.5°C/W</td>
</tr>
<tr>
<td>(\Psi_{JB})</td>
<td>405.9°C/W</td>
</tr>
<tr>
<td>R(_{JC(bot)})</td>
<td>188.3°C/W N/A</td>
</tr>
</tbody>
</table>

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.
6.6 Electrical Characteristics (Dual)

$V_S = 1.8 \text{ V to } 5 \text{ V, } V_{\text{CM}} = V_S / 2$; minimum and maximum values are at $T_A = -40^\circ\text{C to } +125^\circ\text{C}$ (unless otherwise noted). Typical values are at $T_A = 25^\circ\text{C}$.

<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>$V_{\text{IO}}$</td>
<td>$V_S = 1.8 \text{ V and } 5 \text{ V, } V_{\text{CM}} = V_S / 2$</td>
<td>±0.1</td>
<td>±8</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>$V_{\text{HYS}}$</td>
<td>$V_S = 1.8 \text{ V and } 5 \text{ V, } V_{\text{CM}} = V_S / 2$</td>
<td>3</td>
<td>10</td>
<td>25</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{\text{CM}}$</td>
<td>$V_{\text{EE}} \leq V_{\text{CM}} \leq V_{\text{CC}}$, $V_S = 5 \text{ V}$</td>
<td>73</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>$I_{\text{IO}}$</td>
<td>$V_S = 5 \text{ V, } V_{\text{EE}} = 0 \text{ V, } I_O = 3 \text{ mA}$</td>
<td>4.65</td>
<td>4.8</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{OL}}$</td>
<td>$V_S = 5 \text{ V, } V_{\text{EE}} = 0 \text{ V, } I_O = 3 \text{ mA}$</td>
<td>250</td>
<td>350</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>$I_{\text{KG}}$</td>
<td>$V_S = 5 \text{ V, } V_{\text{ID}} = +0.1 \text{ V (output high), } V_{\text{PULLUP}} = V_{\text{CC}}$</td>
<td>100</td>
<td></td>
<td></td>
<td>pA</td>
</tr>
<tr>
<td>CMRR</td>
<td>$V_{\text{EE}} &lt; V_{\text{CM}} &lt; V_{\text{CC}}, V_S = 5 \text{ V}$</td>
<td>73</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>PSRR</td>
<td>$V_S = 1.8 \text{ V to } 5 \text{ V, } V_{\text{CM}} = V_S / 2$</td>
<td>77</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>$I_{\text{SC}}$</td>
<td>$V_S = 5 \text{ V, sourcing (for TLV7032 only)}$</td>
<td>29</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>$V_S = 5 \text{ V, sinking}$</td>
<td>33</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>$I_{\text{CC}}$</td>
<td>$V_S = 1.8 \text{ V, no load, } V_{\text{ID}} = -0.1 \text{ V (Output Low)}$</td>
<td>315</td>
<td>750</td>
<td></td>
<td>nA</td>
</tr>
</tbody>
</table>

6.7 Switching Characteristics (Dual)

Typical values are at $T_A = 25^\circ\text{C, } V_S = 5 \text{ V, } V_{\text{CM}} = V_S / 2$; $CL = 15 \mu\text{F}$, input overdrive = 100 mV (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>$t_{\text{PHL}}$</td>
<td>Midpoint of input to midpoint of output, $V_{\text{ID}} = 100 \text{ mV}$</td>
<td>3</td>
<td></td>
<td></td>
<td>µs</td>
</tr>
<tr>
<td>$t_{\text{PLH}}$</td>
<td>Midpoint of input to midpoint of output, $V_{\text{OD}} = 100 \text{ mV}$</td>
<td>3</td>
<td></td>
<td></td>
<td>µs</td>
</tr>
<tr>
<td>$t_{\text{R}}$</td>
<td>Measured from 20% to 80%</td>
<td>4.5</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>$t_{\text{F}}$</td>
<td>Measured from 20% to 80%</td>
<td>4.5</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>$t_{\text{ON}}$</td>
<td>During power on, $V_{\text{CC}}$ must exceed 1.6V for 200 µs before the output will reflect the input</td>
<td>200</td>
<td></td>
<td></td>
<td>µs</td>
</tr>
</tbody>
</table>

(1) The lower limit for $RP$ is 650 Ω
6.8 Electrical Characteristics (Single)

\( V_S = 1.8 \text{ V to } 5 \text{ V}, \ V_{CM} = V_S / 2; \) minimum and maximum values are at \( T_A = -40^\circ \text{C} \) to +125°C (unless otherwise noted).

Typical values are at \( T_A = 25^\circ \text{C} \).

<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_{IO} )</td>
<td>Input Offset Voltage ( V_S = 1.8 \text{ V and } 5 \text{ V, } V_{CM} = V_S / 2 )</td>
<td>±0.1</td>
<td>±8</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>( V_{HYS} )</td>
<td>Hysteresis ( V_S = 1.8 \text{ V and } 5 \text{ V, } V_{CM} = V_S / 2, \ T_A = 25^\circ \text{C} )</td>
<td>2</td>
<td>7</td>
<td>17</td>
<td>mV</td>
</tr>
<tr>
<td>( V_{CM} )</td>
<td>Common-mode voltage range</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_{B} )</td>
<td>Input bias current</td>
<td>2</td>
<td></td>
<td></td>
<td>pA</td>
</tr>
<tr>
<td>( I_{OS} )</td>
<td>Input offset current</td>
<td>1</td>
<td></td>
<td></td>
<td>pA</td>
</tr>
<tr>
<td>( V_{OH} )</td>
<td>Output voltage high ( \text{for } TLV7031 \text{ only} ) ( V_S = 5 \text{ V, } V_{EE} = 0 \text{ V, } I_O = 3 \text{ mA} )</td>
<td>4.65</td>
<td>4.8</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>( V_{OL} )</td>
<td>Output voltage low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_{KG} )</td>
<td>Open-drain output leakage current ( \text{TLV7041 only} ) ( V_S = 5 \text{ V, } V_{OD} = +0.1 \text{ V (output high), } V_{PULLUP} = V_{CC} )</td>
<td>100</td>
<td></td>
<td></td>
<td>pA</td>
</tr>
<tr>
<td>CMRR</td>
<td>Common-mode rejection ratio ( V_{EE} &lt; V_{CM} &lt; V_{CC}, V_S = 5 \text{ V} )</td>
<td>73</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>PSRR</td>
<td>Power supply rejection ratio ( V_S = 1.8 \text{ V to } 5 \text{ V, } V_{CM} = V_S / 2 )</td>
<td>77</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>( I_{SC} )</td>
<td>Short-circuit current</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_{CC} )</td>
<td>Supply current</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.9 Switching Characteristics (Single)

Typical values are at \( T_A = 25^\circ \text{C}, V_S = 5 \text{ V, } V_{CM} = V_S / 2; \) \( \text{CL} = 15 \text{ pF, input overdrive} = 100 \text{ mV} \) (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>( t_{PHL} )</td>
<td>Propagation delay time, high to low ( \text{RP = 2.5 k}\Omega \text{ TLV7041 only} ) ( \text{Midpoint of input to midpoint of output, } V_{OD} = 100 \text{ mV} )</td>
<td>3</td>
<td></td>
<td></td>
<td>( \mu \text{s} )</td>
</tr>
<tr>
<td>( t_{PLH} )</td>
<td>Propagation delay time, low-to high ( \text{RP = 2.5 k}\Omega \text{ TLV7041 only} ) ( \text{Midpoint of input to midpoint of output, } V_{OD} = 100 \text{ mV} )</td>
<td>3</td>
<td></td>
<td></td>
<td>( \mu \text{s} )</td>
</tr>
<tr>
<td>( t_{\text{R}} )</td>
<td>Rise time ( \text{TLV7031 only} ) ( \text{Measured from 10% to 90%} )</td>
<td>4.5</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>( t_{\text{F}} )</td>
<td>Fall time ( \text{Measured from 10% to 90%} )</td>
<td>4.5</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>( t_{\text{ON}} )</td>
<td>Power-up time ( \text{During power on, } V_{CC} \text{ must exceed 1.6V for } 200 \mu \text{s before the output will reflect the input.} )</td>
<td>200</td>
<td></td>
<td></td>
<td>( \mu \text{s} )</td>
</tr>
</tbody>
</table>
6.10 Timing Diagrams

Figure 1. Start-Up Time Timing Diagram (IN+ > IN–)

Figure 2. Propagation Delay Timing Diagram

NOTE
The propagation delays $t_{PLH}$ and $t_{PHL}$ include the contribution of input offset and hysteresis.
### 6.11 Typical Characteristics

\( T_{A} = 25°C, \ V_{CC} = 5 \ \text{V}, \ V_{EE} = 0 \ \text{V}, \ V_{CM} = \frac{V_{CC}}{2}, \ C_{L} = 15 \ \text{pF} \)

**Figure 3. Input Offset vs Temperature**

\( V_{CC} = 1.8 \ \text{V} \)

**Figure 4. Input Offset vs Temperature**

\( V_{CC} = 3.3 \ \text{V} \)

**Figure 5. Input Offset vs Temperature**

\( V_{CC} = 5 \ \text{V} \)

**Figure 6. Input Offset Voltage vs \( V_{CM} \)**

\( V_{CC} = 1.8 \ \text{V} \)

**Figure 7. Input Offset Voltage vs \( V_{CM} \)**

\( V_{CC} = 3.3 \ \text{V} \)

**Figure 8. Input Offset Voltage vs \( V_{CM} \)**

\( V_{CC} = 5 \ \text{V} \)
Typical Characteristics (continued)

\[ T_A = 25^\circ C, \ V_{CC} = 5 \ V, \ V_{EE} = 0 \ V, \ V_{CM} = \frac{V_{CC}}{2}, \ C_L = 15 \ pF \]

\[ V_{CC} = 1.8 \ V \text{ to } 5 \ V \]

\[ V_{CC} = 3.3 \ V \]

\[ V_{CC} = 5 \ V \]

\[ V_{CC} = 1.8 \ V \text{ to } 5 \ V \]

\[ V_{CC} = 1.8 \ V \]

\[ \text{Figure 9. Hysteresis vs Temperature} \]

\[ \text{Figure 10. Hysteresis vs } V_{CM} \]

\[ \text{Figure 11. Hysteresis vs } V_{CM} \]

\[ \text{Figure 12. Hysteresis vs } V_{CM} \]

\[ \text{Figure 13. Hysteresis vs Temperature} \]

\[ \text{Figure 14. Hysteresis vs } V_{CM} \]

\[ \text{Figure 15. Hysteresis vs Temperature} \]

\[ \text{Figure 16. Hysteresis vs } V_{CM} \]

\[ \text{Figure 17. Hysteresis vs Temperature} \]

\[ \text{Figure 18. Hysteresis vs } V_{CM} \]
Typical Characteristics (continued)

\[ T_A = 25^\circ \text{C}, \ \text{V}_{\text{CC}} = 5 \ \text{V}, \ \text{V}_{\text{EE}} = 0 \ \text{V}, \ \text{V}_{\text{CM}} = V_{\text{CC}}/2, \ C_L = 15 \ \text{pF} \]

**Figure 15. Hysteresis vs \( V_{\text{CM}} \)**

**Figure 16. Hysteresis vs \( V_{\text{CM}} \)**

**Figure 17. Input Bias Current vs Temperature**

**Figure 18. Output Voltage High vs Output Source Current**

**Figure 19. Output Voltage High vs Output Source Current**

**Figure 20. Output Voltage Low vs Output Sink Current**
Typical Characteristics (continued)

\[ T_A = 25^\circ C, \ V_{CC} = 5 \ V, \ V_{EE} = 0 \ V, \ V_{CM} = V_{CC}/2, \ C_L = 15 \ pF \]

\[ V_{CC} = 5 \ V \]

**Figure 21. Output Voltage Low vs Output Sink Current**

**Figure 22. Output Short-Circuit (Sink) Current vs Temperature**

\[ V_{CM} = V_{CC} / 2 \]

**Figure 23. Output Short-Circuit (Source) Current vs Temperature**

**Figure 24. Output Short Circuit (Sink) vs \( V_{CC} \)**

\[ V_{CM} = V_{CC} / 2 \]

**Figure 25. Output Short Circuit (Source) vs \( V_{CC} \)**

**Figure 26. I_{CC} vs Temperature**

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**TLV703x**, **TLV704x**

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Product Folder Links: TLV7031 TLV7032 TLV7041 TLV7042
Typical Characteristics (continued)

\[ T_A = 25^\circ C, \ V_{CC} = 5 \ V, \ V_{EE} = 0 \ V, \ V_{CM} = V_{CC}/2, \ C_L = 15 \ pF \]

**Figure 27.** \( I_{CC} \) vs \( V_{CC} \)

\[ V_{CM} = V_{CC}/2 \]

**Figure 28.** \( I_{CC} \) vs Temperature

\[ V_{OD} = 100 \ mV \]

**Figure 29.** \( I_{CC} \) vs \( V_{CC} \)

**Figure 30.** Rise/Fall Time vs Load Capacitance

**Figure 31.** Propagation Delay (L-H) vs Input Overdrive

**Figure 32.** Propagation Delay (H-L) vs Input Overdrive
7 Detailed Description

7.1 Overview
The TLV703x and TLV704x devices are single-channel, nano-power comparators with push-pull and open-drain outputs. Operating from 1.6 V to 6.5 V and consuming only 315 nA, the TLV703x and TLV704x are designed for portable and industrial applications. The TLV703x and TLV704x are available in an ultra-small X2SON package (0.8 × 0.8 mm) to offer significant board space saving in space-challenged designs.

7.2 Functional Block Diagram

7.3 Feature Description
The TLV703x and TLV704x devices are nanoPower comparators that are capable of operating at low voltages. The TLV703x and TLV704x feature a rail-to-rail input stage capable of operating up to 100 mV beyond the VCC power supply rail. The TLV703x (push-pull) and TLV704x (open-drain) also feature internal hysteresis.

7.4 Device Functional Modes
The TLV703x and TLV704x have a power-on-reset (POR) circuit. While the power supply (V_S) is less than the minimum supply voltage, either upon ramp-up or ramp-down, the POR circuitry is activated.

For the TLV703x, the POR circuit holds the output low (at V_EE) while activated.

For the TLV704x, the POR circuit keeps the output high impedance (logical high) while activated.

When the supply voltage is greater than, or equal to, the minimum supply voltage, the comparator output reflects the state of the differential input (V_ID).
Device Functional Modes (continued)

7.4.1 Inputs

The TLV703x and TLV704x input common-mode extends from $V_{EE}$ to 100 mV above $V_{CC}$. The differential input voltage ($V_{ID}$) can be any voltage within these limits. No phase inversion of the comparator output occurs when the input pins exceed $V_{CC}$ and $V_{EE}$.

The input of TLV703x and TLV704x is fault tolerant. It maintains the same high input impedance when $V_{CC}$ is unpowered or ramping up. The input can be safely driven up to the specified maximum voltage (7 V) with $V_{CC} = 0$ V or any value up to the maximum specified. The $V_{CC}$ is isolated from the input such that it maintains its value even when a higher voltage is applied to the input.

The input bias current is typically 1 pA for input voltages between $V_{CC}$ and $V_{EE}$. The comparator inputs are protected from voltages below $V_{EE}$ by internal diodes connected to $V_{EE}$. As the input voltage goes under $V_{EE}$, the protection diodes become forward biased and begin to conduct causing the input bias current to increase exponentially. Input bias current typically doubles every 10°C temperature increases.

7.4.2 Internal Hysteresis

The device hysteresis transfer curve is shown in Figure 33. This curve is a function of three components: $V_{TH}$, $V_{OS}$, and $V_{HYST}$:

- $V_{TH}$ is the actual set voltage or threshold trip voltage.
- $V_{OS}$ is the internal offset voltage between $V_{IN+}$ and $V_{IN-}$. This voltage is added to $V_{TH}$ to form the actual trip point at which the comparator must respond to change output states.
- $V_{HYST}$ is the internal hysteresis (or trip window) that is designed to reduce comparator sensitivity to noise (7 mV for both TLV703x and TLV704x).

![Hysteresis Transfer Curve](image)

Figure 33. Hysteresis Transfer Curve

7.4.3 Output

The TLV703x features a push-pull output stage eliminating the need for an external pullup resistor. On the other hand, the TLV704x features an open-drain output stage enabling the output logic levels to be pulled up to an external source up to 6.5 V independent of the supply voltage.
8 Application and Implementation

NOTE
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI’s customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The TLV703x and TLV704x are nano-power comparators with reasonable response time. The comparators have a rail-to-rail input stage that can monitor signals beyond the positive supply rail with integrated hysteresis. When higher levels of hysteresis are required, positive feedback can be externally added. The push-pull output stage of the TLV703x is optimal for reduced power budget applications and features no shoot-through current. When level shifting or wire-ORing of the comparator outputs is needed, the TLV704x with its open-drain output stage is well suited to meet the system needs. In either case, the wide operating voltage range, low quiescent current, and small size of the TLV703x and TLV704x make these comparators excellent candidates for battery-operated and portable, handheld designs.

8.1.1 Inverting Comparator With Hysteresis for TLV703x

The inverting comparator with hysteresis requires a three-resistor network that is referenced to the comparator supply voltage (V_{CC}), as shown in Figure 34. When \( V_{IN} \) at the inverting input is less than \( V_A \), the output voltage is high (for simplicity, assume \( V_O \) switches as high as \( V_{CC} \)). The three network resistors can be represented as \( R_1 \parallel R_3 \) in series with \( R_2 \). Equation 1 defines the high-to-low trip voltage (\( V_{A1} \)).

\[
V_{A1} = V_{CC} \times \frac{R_2}{(R_1 \parallel R_3) + R_2}
\]

Equation 1 defines the high-to-low trip voltage (\( V_{A1} \)).

When \( V_{IN} \) is greater than \( V_A \), the output voltage is low, very close to ground. In this case, the three network resistors can be presented as \( R_2 \parallel R_3 \) in series with \( R_1 \). Use Equation 2 to define the low to high trip voltage (\( V_{A2} \)).

\[
V_{A2} = V_{CC} \times \frac{R_2 \parallel R_3}{R_1 + (R_2 \parallel R_3)}
\]

Equation 2 defines the low to high trip voltage (\( V_{A2} \)).

\[
\Delta V_A = V_{A1} - V_{A2}
\]

Equation 3 defines the total hysteresis provided by the network.

Figure 34. TLV703x in an Inverting Configuration With Hysteresis
Application Information (continued)

8.1.2 Noninverting Comparator With Hysteresis for TLV703x

A noninverting comparator with hysteresis requires a two-resistor network, as shown in Figure 35, and a voltage reference ($V_{\text{REF}}$) at the inverting input. When $V_{\text{IN}}$ is low, the output is also low. For the output to switch from low to high, $V_{\text{IN}}$ must rise to $V_{\text{IN1}}$. Use Equation 4 to calculate $V_{\text{IN1}}$.

$$V_{\text{IN1}} = R1 \times \frac{V_{\text{REF}}}{R2} + V_{\text{REF}}$$  \hspace{1cm} (4)

When $V_{\text{IN}}$ is high, the output is also high. For the comparator to switch back to a low state, $V_{\text{IN}}$ must drop to $V_{\text{IN2}}$ such that $V_A$ is equal to $V_{\text{REF}}$. Use Equation 5 to calculate $V_{\text{IN2}}$.

$$V_{\text{IN2}} = \frac{V_{\text{REF}} (R1 + R2) - V_{\text{CC}} \times R1}{R2}$$  \hspace{1cm} (5)

The hysteresis of this circuit is the difference between $V_{\text{IN1}}$ and $V_{\text{IN2}}$, as shown in Equation 6.

$$\Delta V_{\text{IN}} = V_{\text{CC}} \times \frac{R1}{R2}$$  \hspace{1cm} (6)

![Figure 35. TLV703x in a Noninverting Configuration With Hysteresis](image-url)
8.2 Typical Applications

8.2.1 Window Comparator

Window comparators are commonly used to detect undervoltage and overvoltage conditions. Figure 36 shows a simple window comparator circuit.

![Figure 36. TLV704x-Based Window Comparator](image)

### 8.2.1.1 Design Requirements

For this design, follow these design requirements:

- Alert (logic low output) when an input signal is less than 1.1 V
- Alert (logic low output) when an input signal is greater than 2.2 V
- Alert signal is active low
- Operate from a 3.3-V power supply

### 8.2.1.2 Detailed Design Procedure

Configure the circuit as shown in Figure 36. Connect \( V_{CC} \) to a 3.3-V power supply and \( V_{EE} \) to ground. Make \( R_1 \), \( R_2 \), and \( R_3 \) each 10-M\( \Omega \) resistors. These three resistors are used to create the positive and negative thresholds for the window comparator (\( V_{TH+} \) and \( V_{TH-} \)). With each resistor being equal, \( V_{TH+} \) is 2.2 V and \( V_{TH-} \) is 1.1 V. Large resistor values such as 10 M\( \Omega \) are used to minimize power consumption. The sensor output voltage is applied to the inverting and noninverting inputs of the two TLV704x devices. The TLV704x is used for its open-drain output configuration. Using the TLV704x allows the two comparator outputs to be wire-ored together. The respective comparator outputs are low when the sensor is less than 1.1 V or greater than 2.2 V. \( V_{OUT} \) is high when the sensor is in the range of 1.1 V to 2.2 V.
Typical Applications (continued)

8.2.1.3 Application Curve

![Graph showing the application curve for the TLV703x device.]

8.2.2 IR Receiver Analog Front End

A single TLV703x device can be used to build a complete IR receiver analog front end (AFE). The nanoamp quiescent current and low input bias current make it possible to be powered with a coin cell battery, which could last for years.

![Diagram of the IR Receiver Analog Front End using TLV703x.]

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8.2.2.1 Design Requirements

For this design, follow these design requirements:

- Use a proper resistor (R1) value to generate an adequate signal amplitude applied to the inverting input of the comparator.
- The low input bias current I_B (2 pA typical) ensures that a greater value of R1 to be used.
- The RC constant value (R2 and C1) must support the targeted data rate (that is, 9,600 bauds) in order to maintain a valid tripping threshold.
- The hysteresis introduced with R3 and R4 helps to avoid spurious output toggles.
Typical Applications (continued)

8.2.2.2 Detailed Design Procedure

The IR receiver AFE design is highly streamlined and optimized. $R_1$ converts the IR light energy induced current into voltage and applies to the inverting input of the comparator. The RC network of $R_2$ and $C_1$ establishes a reference voltage $V_{\text{ref}}$, which tracks the mean amplitude of the IR signal. The noninverting input is directly connected to $V_{\text{ref}}$ through $R_3$. $R_3$ and $R_4$ are used to produce a hysteresis to keep transitions free of spurious toggles. To reduce the current drain from the coin cell battery, data transmission must be short and infrequent.

More technical details are provided in the TI TechNote *Low Power Comparator for Signal Processing and Wake-Up Circuit in Smart Meters* (SNVA808).

8.2.2.3 Application Curve

![Figure 39. IR Receiver AFE Waveforms](image-url)
Typical Applications (continued)

8.2.3 Square-Wave Oscillator

A square-wave oscillator can be used as low-cost timing reference or system supervisory clock source.

![Square-Wave Oscillator Diagram]

8.2.3.1 Design Requirements

The square-wave period is determined by the RC time constant of the capacitor and resistor. The maximum frequency is limited by the propagation delay of the device and the capacitance load at the output. The low input bias current allows a lower capacitor value and larger resistor value combination for a given oscillator frequency, which may help reduce BOM cost and board space.

8.2.3.2 Detailed Design Procedure

The oscillation frequency is determined by the resistor and capacitor values. The following section provides details to calculate these component values.

![Square-Wave Oscillator Timing Thresholds Diagram]

First consider the output of figure Figure 40 is high, which indicates the inverted input $V_C$ is lower than the noninverting input ($V_A$). This causes the $C_1$ to be charged through $R_4$, and the voltage $V_C$ increases until it is equal to the noninverting input. The value of $V_A$ at the point is calculated by Equation 7.

$$V_{A1} = \frac{V_{CC} \times R_2}{R_2 + R_1 + R_3}$$

If $R_1 = R_2 = R_3$, then $V_{A1} = 2 \frac{V_{CC}}{3}$
Typical Applications (continued)

At this time the comparator output trips pulling down the output to the negative rail. The value of \( V_A \) at this point is calculated by Equation 8.

\[
V_{A2} = \frac{V_{CC}(R_2IR_3)}{R_1+R_2IR_3}
\]  

(8)

If \( R_1 = R_2 = R_3 \), then \( V_{A2} = V_{CC}/3 \)

The \( C_1 \) now discharges though the \( R_4 \), and the voltage \( V_{CC} \) decreases until it reaches \( V_{A2} \). At this point, the output switches back to the starting state. The oscillation period equals the time duration from \( 2V_{CC}/3 \) to \( V_{CC}/3 \) then back to \( 2V_{CC}/3 \), which is given by \( R_4C_1 \times \ln2 \) for each trip. Therefore, the total time duration is calculated as \( 2R_4C_1 \times \ln2 \). The oscillation frequency can be obtained by Equation 9:

\[
f = \frac{1}{2 R_4C_1 \times \ln2}
\]  

(9)

8.2.3.3 Application Curve

Figure 42 shows the simulated results of an oscillator using the following component values:

- \( R_1 = R_2 = R_3 = R_4 = 100 \, \text{k}\Omega \)
- \( C_1 = 100 \, \text{pF}, C_L = 20 \, \text{pF} \)
- \( V_+ = 5 \, \text{V}, V_- = \text{GND} \)
- \( C_{\text{stray}} \) (not shown) from \( V_A \) to \( \text{GND} = 10 \, \text{pF} \)

![Figure 42. Square-Wave Oscillator Output Waveform](image-url)
Typical Applications (continued)

8.2.4 Quadrature Rotary Encoder

A quadrature encoder for rotary motors/shafts utilizing a Tunneling Magnetoresistance (TMR) Rotation Sensor can track the position of the motor shaft even when power is turned off, while the TLV7032 provides additional hysteresis to prevent unwanted output toggling between quadrants. The TLV7032 can be used with other sensing techniques as well, such as optical, capacitive, or inductive.

Figure 43. Quadrant Encoder Detector

8.2.4.1 Design Requirements

TMR Rotation Sensors generally have two digital, binary outputs that are 90 degrees out of phase. The TLV7032 can be used to provide additional hysteresis to ensure there isn’t any unwanted toggling of the output when the sensors are between the transition points of two quadrants. The TLV7032 already provides 10mV of typical internal hysteresis. By dividing down the output voltage from the rotation sensor using a voltage divider, the internal hysteresis will be scaled up by the same voltage divider ratio.

Figure 44. Voltage Divider Equation
Typical Applications (continued)

8.2.4.2 Detailed Design Procedure

First, choose a target range of hysteresis to achieve. For this design example, 50mV of hysteresis will be the target. Since the TLV7032 already has 10mV (typ) of internal hysteresis, the voltage output from the TMR Rotation Sensor should be scaled down by a factor of 5. This way, the 10mV of internal hysteresis gets scaled up by a factor of 5, resulting in 50mV of hysteresis. The minimum output HIGH level for the TMR Rotation Sensor used in Figure 47 is 5.25 V. Since 5.25V will be the minimum output high value, it can be used to substitute \( V_{IN} \) from the Voltage Divider Equation in Figure 48. Since the voltage from the TMR rotation sensor needs to be scaled down by a factor of 5, the equation in Figure 48 can be rewritten as:

\[
\frac{1}{5} \frac{R_2}{R_1 + R_2}
\]

The above equation can be solved for using standard resistor values, where \( R_1 = 100k\Omega \) and \( R_2 = 24.9k\Omega \). The minimum voltage seen at the noninverting pins of the comparator when the output is HIGH will be 1.05V. To make the device transition at 50% output high level, the inverting pins of the TLV7032 should be tied to a 0.525V reference.

8.2.4.3 Application Curve

Figure 49 shows the TLV7032 achieving approximately 50mV of hysteresis using the following component values:

- \( R_1 = 100k\Omega \)
- \( R_2 = 24.9k\Omega \)
- \( V_{REF} (IN-) = 0.525V \)

![Figure 45. DC Input Voltage Sweep](image)
9 Power Supply Recommendations

The TLV703x and TLV704x have a recommended operating voltage range \((V_S)\) of 1.6 V to 6.5 V. \(V_S\) is defined as \(V_{CC} - V_{EE}\). Therefore, the supply voltages used to create \(V_S\) can be single-ended or bipolar. For example, single-ended supply voltages of 5 V and 0 V and bipolar supply voltages of +2.5 V and –2.5 V create comparable operating voltages for \(V_S\). However, when bipolar supply voltages are used, it is important to realize that the logic low level of the comparator output is referenced to \(V_{EE}\).

Output capacitive loading and output toggle rate will cause the average supply current to rise over the quiescent current.

10 Layout

10.1 Layout Guidelines

To reduce PCB fabrication cost and improve reliability, TI recommends using a 4-mil via at the center pad connected to the ground trace or plane on the bottom layer.

TI recommends a power-supply bypass capacitor of 100 nF when supply output impedance is high, supply traces are long, or when excessive noise is expected on the supply lines. Bypass capacitors are also recommended when the comparator output drives a long trace or is required to drive a capacitive load. Due to the fast rising and falling edge rates and high-output sink and source capability of the TLV703x and TLV704x output stages, higher than normal quiescent current can be drawn from the power supply. Under this circumstance, the system would benefit from a bypass capacitor across the supply pins.

10.2 Layout Example

![Layout Example](image)

The application report *Designing and Manufacturing With TI’s X2SON Packages* (SCEA055) helps PCB designers to achieve optimal designs.
11 Device and Documentation Support

11.1 Device Support

11.1.1 Development Support

11.1.1.1 Evaluation Module

An evaluation module (EVM) is available to assist in the initial circuit performance evaluation using the TLV70x1 device family. The TLV7011 Micro-Power Comparator Dip Adaptor Evaluation Module can be requested at the Texas Instruments website through the product folder or purchased directly from the TI eStore.

11.2 Documentation Support

11.2.1 Related Documentation

For related documentation, see the following:
- Designing and Manufacturing With TI's X2SON Packages (SCEA055)
- Low Power Comparator for Signal Processing and Wake-Up Circuit in Smart Meters (SNVA808)

11.3 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to order now.

<table>
<thead>
<tr>
<th>PARTS</th>
<th>PRODUCT FOLDER</th>
<th>ORDER NOW</th>
<th>TECHNICAL DOCUMENTS</th>
<th>TOOLS &amp; SOFTWARE</th>
<th>SUPPORT &amp; COMMUNITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLV7031</td>
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<td>Click here</td>
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</table>

11.4 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on Alert me to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

11.5 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community TI's Engineer-to-Engineer (E2E) Community. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support TI's Design Support Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.6 Trademarks

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11.7 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

11.8 Glossary

SLYZ022 — TI Glossary.

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.
### 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/Ball Finish (6)</th>
<th>MSL Peak Temp (3)</th>
<th>Op Temp (°C)</th>
<th>Device Marking (4/5)</th>
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<td>DGK</td>
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<td>2500</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
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<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>7032</td>
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<td>DBV</td>
<td>5</td>
<td>3000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
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<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>1IF2</td>
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<td>SC70</td>
<td>DCK</td>
<td>5</td>
<td>3000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
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<td>Level-2-260C-1 YEAR</td>
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<td>5</td>
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<td>Level-2-260C-1 YEAR</td>
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<tr>
<td>TLV7041DPWR</td>
<td>ACTIVE</td>
<td>X2SON</td>
<td>DPW</td>
<td>5</td>
<td>3000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
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<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
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</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.
- **NRND**: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
- **PREVIEW**: Device has been announced but is not in production. Samples may or may not be available.
- **OBSOLETE**: TI has discontinued the production of the device.

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

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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.
# TAPE AND REEL INFORMATION

*All dimensions are nominal.

<table>
<thead>
<tr>
<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>
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<td>4.0</td>
<td>8.0</td>
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<td>9.0</td>
<td>2.4</td>
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<td>8.0</td>
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## TAPE AND REEL BOX DIMENSIONS

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<tr>
<th>Device</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>SPQ</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
<th>Height (mm)</th>
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<tbody>
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<td>205.0</td>
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</table>

*All dimensions are nominal*
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. Mold flash and protrusion shall not exceed 0.15 per side.
D. Falls within JEDEC MO-203 variation AA.
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
D. Publication IPC-7351 is recommended for alternate designs.
E. 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. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.
Images above are just a representation of the package family, actual package may vary. Refer to the product data sheet for package details.
NOTES:
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The size and shape of this feature may vary.
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, refer to QFN/SON PCB application note in literature No. SLUA271 (www.ti.com/lit/slua271).
5. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.
DGK (S–PDSO–G8)  PLASTIC SMALL–OUTLINE PACKAGE

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
E. Falls within JEDEC MO–187 variation AA, except interlead flash.
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.  
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.
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