# SN74HC04-Q1 汽车类六路逆变器

## 1 特性

- 符合面向汽车 应用的 AEC-Q100 标准：
  - 器件温度等级 1：
    –40°C 至 +125°C，$T_A$
- 缓冲输入
- 正负输入钳位二极管
- 宽工作电压范围：2V 至 6V
- 支持多达 10 个 LSTTL 负载的扇出
- 与 LSTTL 逻辑 IC 相比，可显著降低功耗

## 2 应用

- 同步反相时钟输入
- 对数字信号进行反相

## 3 说明

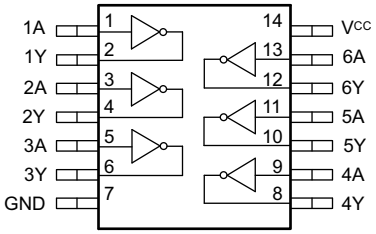
此器件包含六个独立的逆变器。每个逻辑门以正逻辑执行布尔函数 $Y = \overline{A}$。

**器件信息(1)**

| 器件型号 | 封装 | 封装尺寸（标称值） |
|---|---|---|
| SN74HC04IPWRG4Q1 | TSSOP (14) | 5.00mm × 4.40mm |

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。

**SN74HC04-Q1 的功能引脚**




本文档旨在为方便起见，提供有关 TI 产品中文版本的信息，以确认产品的概要。 有关适用的官方英文版本的最新信息，请访问 www.ti.com，其内容始终优先。 TI 不保证翻译的准确性和有效性。 在实际设计之前，请务必参考最新版本的英文版本。

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## 4 修订历史记录

注：之前版本的页码可能与当前版本有所不同。

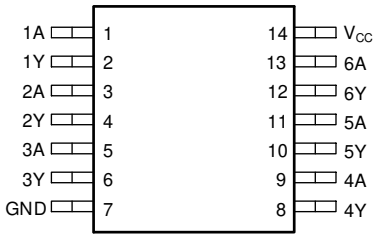
**Changes from Revision A (April 2008) to Revision B** **Page**

- 更新至全新数据表标准 ... 1
- Deleted Q version of device from Electrical Specifications as it is no longer available ... 4
- Changed $R_{\theta JA}$ for PW package from 113 °C/W to 151.7 °C/W ... 4


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# 5 Pin Configuration and Functions

**PW Package**
**14-Pin TSSOP**
**Top View**




**Pin Functions**

| PIN | | I/O | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| 1A | 1 | Input | Channel 1, Input A |
| 1Y | 2 | Output | Channel 1, Output Y |
| 2A | 3 | Input | Channel 2, Input A |
| 2Y | 4 | Output | Channel 2, Output Y |
| 3A | 5 | Input | Channel 3, Input A |
| 3Y | 6 | Output | Channel 3, Output Y |
| GND | 7 | — | Ground |
| 4Y | 8 | Output | Channel 4, Output Y |
| 4A | 9 | Input | Channel 4, Input A |
| 5Y | 10 | Output | Channel 5, Output Y |
| 5A | 11 | Input | Channel 5, Input A |
| 6Y | 12 | Output | Channel 6, Output Y |
| 6A | 13 | Input | Channel 6, Input A |
| $V_{CC}$ | 14 | — | Positive Supply |

# 6 Specifications

## 6.1 Absolute Maximum Ratings

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

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | | –0.5 | 7 | V |
| $I_{IK}$ | Input clamp current(2) | $V_I < 0$ or $V_I > V_{CC}$ | | ±20 | mA |
| $I_{OK}$ | Output clamp current(2) | $V_O < 0$ or $V_O > V_{CC}$ | | ±20 | mA |
| $I_O$ | Continuous output current | $V_O = 0$ to $V_{CC}$ | | ±25 | mA |
| | Continuous current through $V_{CC}$ or GND | | | ±50 | mA |
| $T_J$ | Junction temperature(3) | | | 150 | °C |
| $T_{stg}$ | Storage temperature | | –65 | 150 | °C |

(1) Stresses beyond those listed under *Absolute Maximum Rating* 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 Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) The input and output voltage ratings may be exceeded if the input and output current ratings are observed.
(3) Guaranteed by design.

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## 6.2 ESD Ratings

| | | | VALUE | UNIT |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human body model (HBM), per AEC Q100-002 (1) HBM ESD Classification Level 2 | ±2000 | V |
| | | Charged device model (CDM), per AEC Q100-011 CDM ESD Classification Level C6 | ±1000 | |

(1) AEC Q100-002 indicate that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

## 6.3 Recommended Operating Conditions

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

| | | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | | 2 | 5 | 6 | V |
| $V_{IH}$ | High-level input voltage | $V_{CC}$ = 2 V | 1.5 | | | V |
| | | $V_{CC}$ = 4.5 V | 3.15 | | | |
| | | $V_{CC}$ = 6 V | 4.2 | | | |
| $V_{IL}$ | Low-level input voltage | $V_{CC}$ = 2 V | | | 0.5 | V |
| | | $V_{CC}$ = 4.5 V | | | 1.35 | |
| | | $V_{CC}$ = 6 V | | | 1.8 | |
| $V_I$ | Input voltage | | 0 | | $V_{CC}$ | V |
| $V_O$ | Output voltage | | 0 | | $V_{CC}$ | V |
| $\Delta t/\Delta v$ | Input transition rise and fall rate | $V_{CC}$ = 2 V | | | 1000 | ns |
| | | $V_{CC}$ = 4.5 V | | | 500 | |
| | | $V_{CC}$ = 6 V | | | 400 | |
| $T_A$ | Operating free-air temperature | SN74HC04I-Q1 | –40 | | 85 | °C |

## 6.4 Thermal Information

| THERMAL METRIC | | SN74HC04-Q1 PW (TSSOP) 14 PINS | UNIT |
|---|---|---|---|
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 151.7 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 79.4 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 94.7 | °C/W |
| $\Psi_{JT}$ | Junction-to-top characterization parameter | 25.2 | °C/W |
| $\Psi_{JB}$ | Junction-to-board characterization parameter | 94.1 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | N/A | °C/W |


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## 6.5 Electrical Characteristics

over operating free-air temperature range; typical values measured at $T_A$ = 25°C (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | | $V_{CC}$ | Operating free-air temperature ($T_A$) | | | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 25°C | | | -40°C to 85°C | | | |
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{OH}$ | High-level output voltage | $V_I$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = -20 µA | 2 V | 1.9 | 1.998 | | 1.9 | | | V |
| | | | | 4.5 V | 4.4 | 4.499 | | 4.4 | | | |
| | | | | 6 V | 5.9 | 5.999 | | 5.9 | | | |
| | | | $I_{OH}$ = -4 mA | 4.5 V | 3.98 | 4.3 | | 3.84 | | | |
| | | | $I_{OH}$ = -5.2 mA | 6 V | 5.48 | 5.8 | | 5.34 | | | |
| $V_{OL}$ | Low-level output voltage | $V_I$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 20 µA | 2 V | | 0.002 | 0.1 | | | 0.1 | V |
| | | | | 4.5 V | | 0.001 | 0.1 | | | 0.1 | |
| | | | | 6 V | | 0.001 | 0.1 | | | 0.1 | |
| | | | $I_{OL}$ = 4 mA | 4.5 V | | 0.17 | 0.26 | | | 0.33 | |
| | | | $I_{OL}$ = 5.2 mA | 6 V | | 0.15 | 0.26 | | | 0.33 | |
| $I_I$ | Input leakage current | $V_I$ = $V_{CC}$ or 0 | | 6 V | | ±0.1 | ±100 | | | ±1000 | nA |
| $I_{CC}$ | Supply current | $V_I$ = $V_{CC}$ or 0 | $I_O$ = 0 | 6 V | | | 2 | | | 20 | µA |
| $C_i$ | Input capacitance | | | 2 V to 6 V | | 3 | 10 | | | 10 | pF |

## 6.6 Switching Characteristics

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

| PARAMETER | | FROM | TO | $V_{CC}$ | Operating free-air temperature ($T_A$) | | | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 25°C | | | –40°C to 85°C | | | |
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $t_{pd}$ | Propagation delay | A or B | Y | 2 V | | 45 | 95 | | | 120 | ns |
| | | | | 4.5 V | | 9 | 19 | | | 24 | |
| | | | | 6 V | | 8 | 16 | | | 20 | |
| $t_t$ | Transition-time | | Y | 2 V | | 38 | 75 | | | 95 | ns |
| | | | | 4.5 V | | 8 | 15 | | | 19 | |
| | | | | 6 V | | 6 | 13 | | | 16 | |

## 6.7 Operating Characteristics

over operating free-air temperature range; typical values measured at $T_A$ = 25°C (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $C_{pd}$ | Power dissipation capacitance per gate | No load | | 20 | | pF |

## 6.8 Typical Characteristics

$T_A$ = 25°C

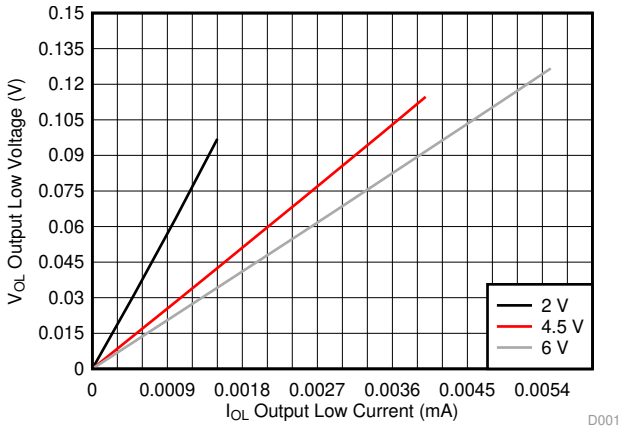



**图 1. Output voltage versus output current in low state**

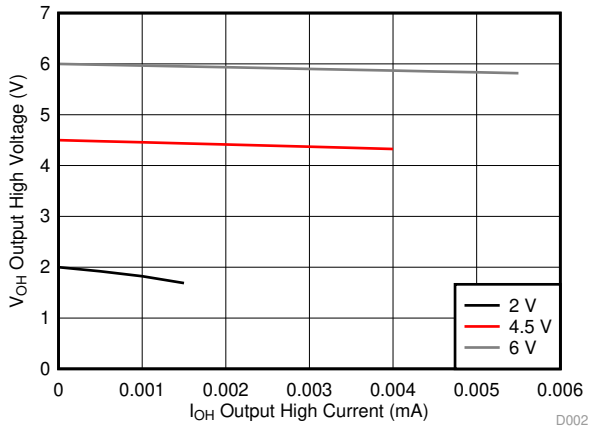
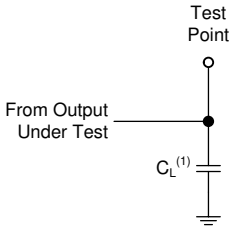



**图 2. Output voltage versus output current in high state**

# 7 Parameter Measurement Information

- Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics: PRR ≤ 1 MHz, $Z_O$ = 50 Ω, $t_t$ < 6 ns.
- The outputs are measured one at a time, with one input transition per measurement.




$C_L$= 50 pF and includes probe and jig capacitance.

**图 3. Load Circuit**

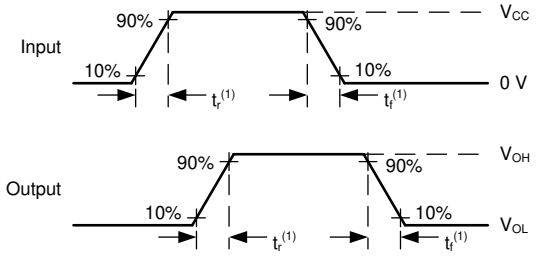
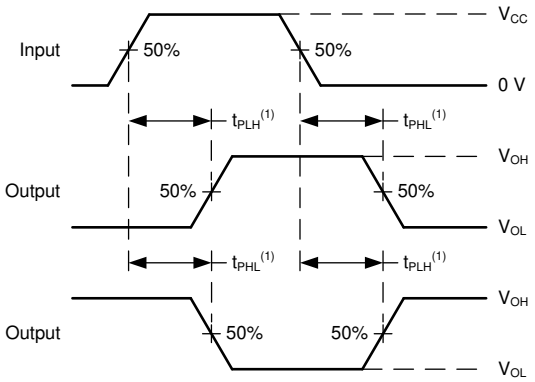



**图 4. Voltage Waveforms Transition Times**




The maximum between $t_{PLH}$ and $T_{PHL}$ is used for $t_{pd}$.

**图 5. Voltage Waveforms Propagation Delays**

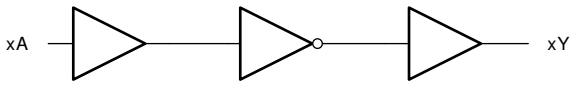

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# 8 Detailed Description

## 8.1 Overview

This device contains six independent inverters. Each gate performs the Boolean function $Y = \overline{A}$ in positive logic.

## 8.2 Functional Block Diagram




## 8.3 Feature Description

### 8.3.1 Balanced CMOS Push-Pull Outputs

A balanced output allows the device to sink and source similar currents. The drive capability of this device may create fast edges into light loads so routing and load conditions should be considered to prevent ringing. Additionally, the outputs of this device are capable of driving larger currents than the device can sustain without being damaged. It is important for the output power of the device to be limited to avoid damage due to over-current. The electrical and thermal limits defined in the *Absolute Maximum Ratings* must be followed at all times.

The SN74HC04-Q1 can drive a load with a total capacitance less than or equal to 50 pF connected to a high-impedance CMOS input while still meeting all of the datasheet specifications. Larger capacitive loads can be applied, however it is not recommended to exceed 70 pF. If larger capacitive loads are required, it is recommended to add a series resistor between the output and the capacitor to limit output current to the values given in the *Absolute Maximum Ratings*.

### 8.3.2 Standard CMOS Inputs

Standard CMOS inputs are high impedance and are typically modeled as a resistor from the input to ground in parallel with the input capacitance given in the *Electrical Characteristics*. The worst case resistance is calculated with the maximum input voltage, given in the *Absolute Maximum Ratings*, and the maximum input leakage current, given in the *Electrical Characteristics*, using ohm's law ($R = V \div I$).

Signals applied to the inputs need to have fast edge rates, as defined by $\Delta t/\Delta v$ in the *Recommended Operating Conditions* to avoid excessive current consumption and oscillations. If a slow or noisy input signal is required, a device with a Schmitt-trigger input should be used to condition the input signal prior to the standard CMOS input.

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## Feature Description (接下页)

### 8.3.3 Clamp Diode Structure

The inputs and outputs to this device have both positive and negative clamping diodes as depicted in 图 6.

**CAUTION**

Voltages beyond the values specified in the Absolute Maximum Ratings table can cause damage to the device. The recommended input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.

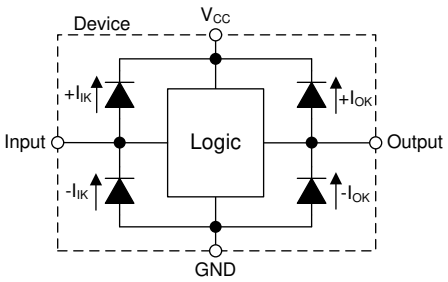



**图 6. Electrical Placement of Clamping Diodes for Each Input and Output**

## 8.4 Device Functional Modes

**表 1. Function Table**

| INPUT | OUTPUT |
|---|---|
| A | Y |
| L | H |
| H | L |


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# 9 Application and Implementation

**注**

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.

## 9.1 Application Information

The SN74HC04-Q1 can be used to add an additional stage to a counter with an external flip-flop. Because counters use a negative edge trigger, the flip-flop's clock input must be inverted to provide this function. This function only requires one of the six available inverters in the SN74HC04-Q1 device, so the remaining channels can be used for other applications needing an inverted signal or improved signal integrity. Unused inputs must be terminated at $V_{CC}$ or GND. Unused outputs can be left floating.

## 9.2 Typical Application

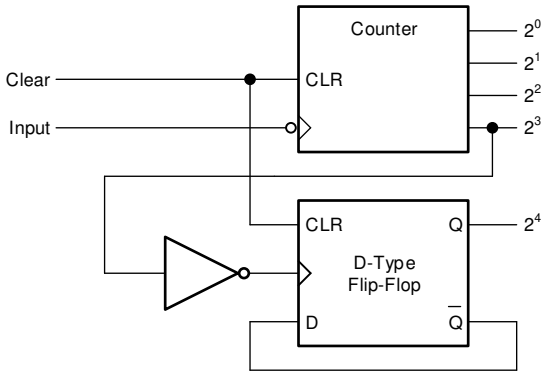



**图 7. Typical application block diagram**

### 9.2.1 Design Requirements

#### *9.2.1.1 Power Considerations*

Ensure the desired supply voltage is within the range specified in the *Recommended Operating Conditions*. The supply voltage sets the device's electrical characteristics as described in the *Electrical Characteristics*.

The supply must be capable of sourcing current equal to the total current to be sourced by all outputs of the SN74HC04-Q1 plus the maximum supply current, $I_{CC}$, listed in the *Electrical Characteristics*. The logic device can only source or sink as much current as it is provided at the supply and ground pins, respectively. Be sure not to exceed the maximum total current through GND or $V_{CC}$ listed in the *Absolute Maximum Ratings*.

Total power consumption can be calculated using the information provided in CMOS Power Consumption and $C_{pd}$ Calculation.

Thermal increase can be calculated using the information provided in Thermal Characteristics of Standard Linear and Logic (SLL) Packages and Devices.

**CAUTION**

The maximum junction temperature, $T_J$(max) listed in the *Absolute Maximum Ratings*, is an *additional limitation* to prevent damage to the device. Do not violate any values listed in the *Absolute Maximum Ratings*. These limits are provided to prevent damage to the device.

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## Typical Application (接下页)

### 9.2.1.2 Input Considerations

Unused inputs must be terminated to either $V_{CC}$ or ground. These can be directly terminated if the input is completely unused, or they can be connected with a pull-up or pull-down resistor if the input is to be used sometimes, but not always. A pull-up resistor is used for a default state of HIGH, and a pull-down resistor is used for a default state of LOW. The resistor size is limited by drive current of the controller, leakage current into the SN74HC04-Q1, as specified in the *Electrical Characteristics*, and the desired input transition rate. A 10-kΩ resistor value is often used due to these factors.

The SN74HC04-Q1 has standard CMOS inputs, so input signal edge rates cannot be slow. Slow input edge rates can cause oscillations and damaging shoot-through current. The recommended rates are defined in the *Recommended Operating Conditions*.

Refer to the *Feature Description* for additional information regarding the inputs for this device.

### 9.2.1.3 Output Considerations

The positive supply voltage is used to produce the output HIGH voltage. Drawing current from the output will decrease the output voltage as specified by the $V_{OH}$ specification in the *Electrical Characteristics*. Similarly, the ground voltage is used to produce the output LOW voltage. Sinking current into the output will increase the output voltage as specified by the $V_{OL}$ specification in the *Electrical Characteristics*.

Unused outputs can be left floating. Do not connect outputs directly to $V_{CC}$ or ground.

Refer to *Feature Description* for additional information regarding the outputs for this device.

### 9.2.2 Detailed Design Procedure

1. Add a decoupling capacitor from $V_{CC}$ to GND. The capacitor needs to be placed physically close to the device and electrically close to both the $V_{CC}$ and GND pins. An example layout is shown in the *Layout*.
2. Ensure the capacitive load at the output is ≤ 70 pF. This is not a hard limit, however it will ensure optimal performance. This can be accomplished by providing short, appropriately sized traces from the SN74HC04-Q1 to the receiving device.
3. Ensure the resistive load at the output is larger than ($V_{CC}$ / $I_O$(max)) Ω. This will ensure that the maximum output current from the *Absolute Maximum Ratings* is not violated. Most CMOS inputs have a resistive load measured in megaohms; much larger than the minimum calculated above.
4. Thermal issues are rarely a concern for logic gates, however the power consumption and thermal increase can be calculated using the steps provided in the application report, CMOS Power Consumption and Cpd Calculation

### 9.2.3 Application Curves

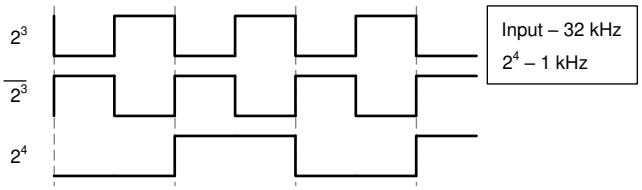



**图 8. Application timing diagram**


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# 10 Power Supply Recommendations

The power supply can be any voltage between the minimum and maximum supply voltage rating located in the *Recommended Operating Conditions*. Each $V_{CC}$ terminal should have a bypass capacitor to prevent power disturbance. A 0.1-μF capacitor is recommended for this device. It is acceptable to parallel multiple bypass caps to reject different frequencies of noise. The 0.1-μF and 1-μF capacitors are commonly used in parallel. The bypass capacitor should be installed as close to the power terminal as possible for best results, as shown in *图 9*.

# 11 Layout

## 11.1 Layout Guidelines

When using multiple-input and multiple-channel logic devices inputs must not ever be left floating. In many cases, functions or parts of functions of digital logic devices are unused; for example, when only two inputs of a triple-input AND gate are used. Such unused input pins must not be left unconnected because the undefined voltages at the outside connections result in undefined operational states. All unused inputs of digital logic devices must be connected to a logic high or logic low voltage, as defined by the input voltage specifications, to prevent them from floating. The logic level that must be applied to any particular unused input depends on the function of the device. Generally, the inputs are tied to GND or $V_{CC}$, whichever makes more sense for the logic function or is more convenient.

## 11.2 Layout Example

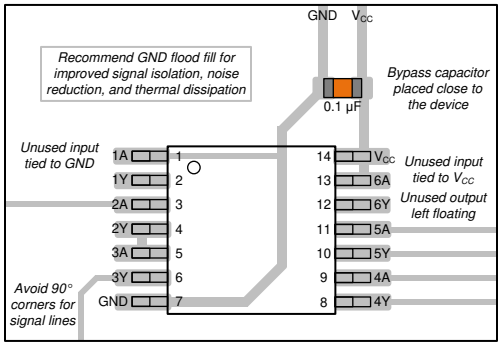



**图 9. Example layout for the SN74HC04-Q1**

# 12 器件和文档支持

## 12.1 文档支持

### 12.1.1 相关文档

请参阅如下相关文档：

- 《HCMOS 设计注意事项》
- 《CMOS 功耗与 CPD 计算》
- 《使用逻辑器件进行设计》

## 12.2 相关链接

下表列出了快速访问链接。类别包括技术文档、支持与社区资源、工具和软件，以及申请样片或购买产品的快速链接。

## 12.3 社区资源

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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## 12.5 静电放电警告

这些装置包含有限的内置 ESD 保护。 存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

## 12.6 Glossary

SLYZ022 — *TI Glossary*.

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

# 13 机械、封装和可订购信息

以下页面包含机械、封装和可订购信息。这些信息是指定器件的最新可用数据。数据如有变更，恕不另行通知，且不会对此文档进行修订。如需获取此数据表的浏览器版本，请查阅左侧的导航栏。


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## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SN74HC04IPWRG4Q1 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | HC04I | Samples |

(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.

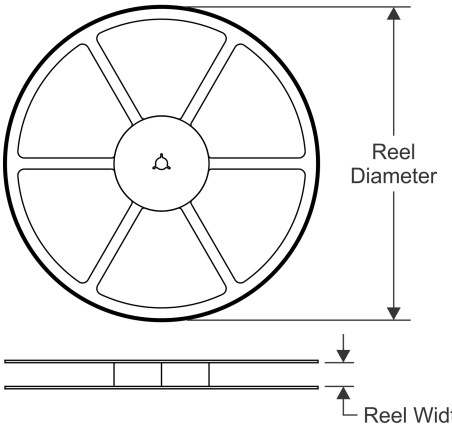
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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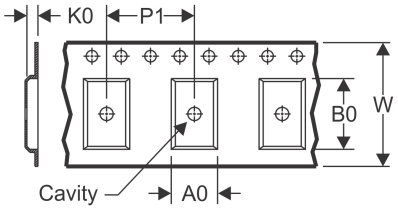
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## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

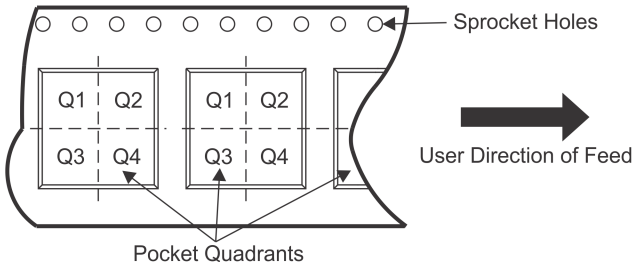



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

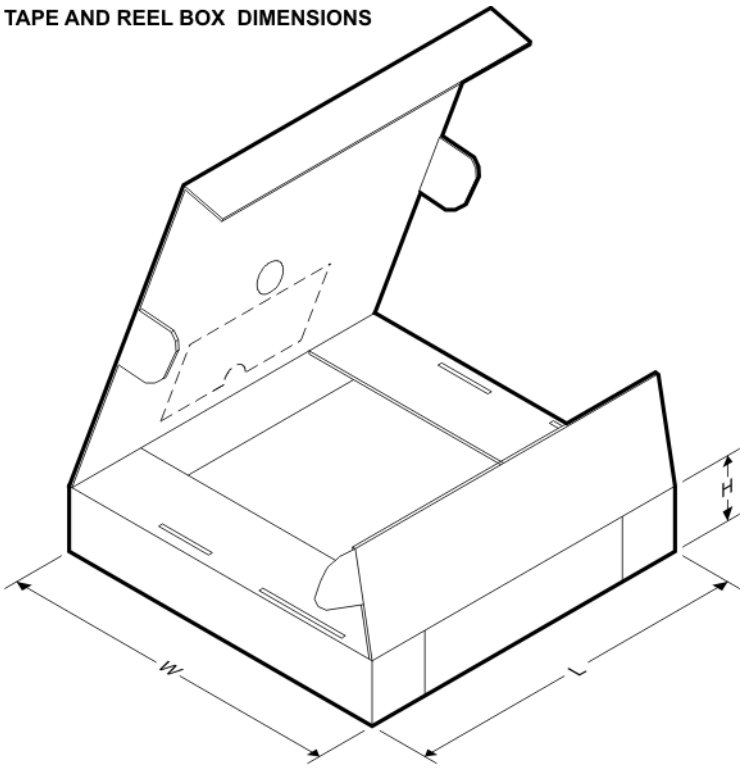
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SN74HC04IPWRG4Q1 | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |

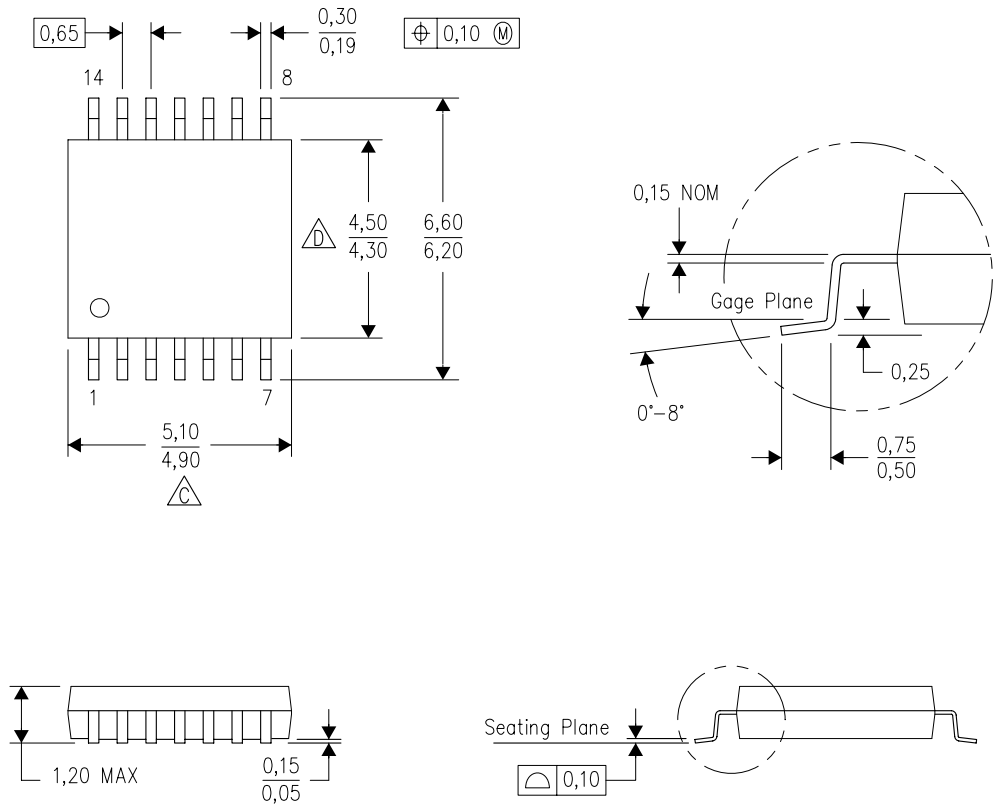
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| SN74HC04IPWRG4Q1 | TSSOP | PW | 14 | 2000 | 853.0 | 449.0 | 35.0 |

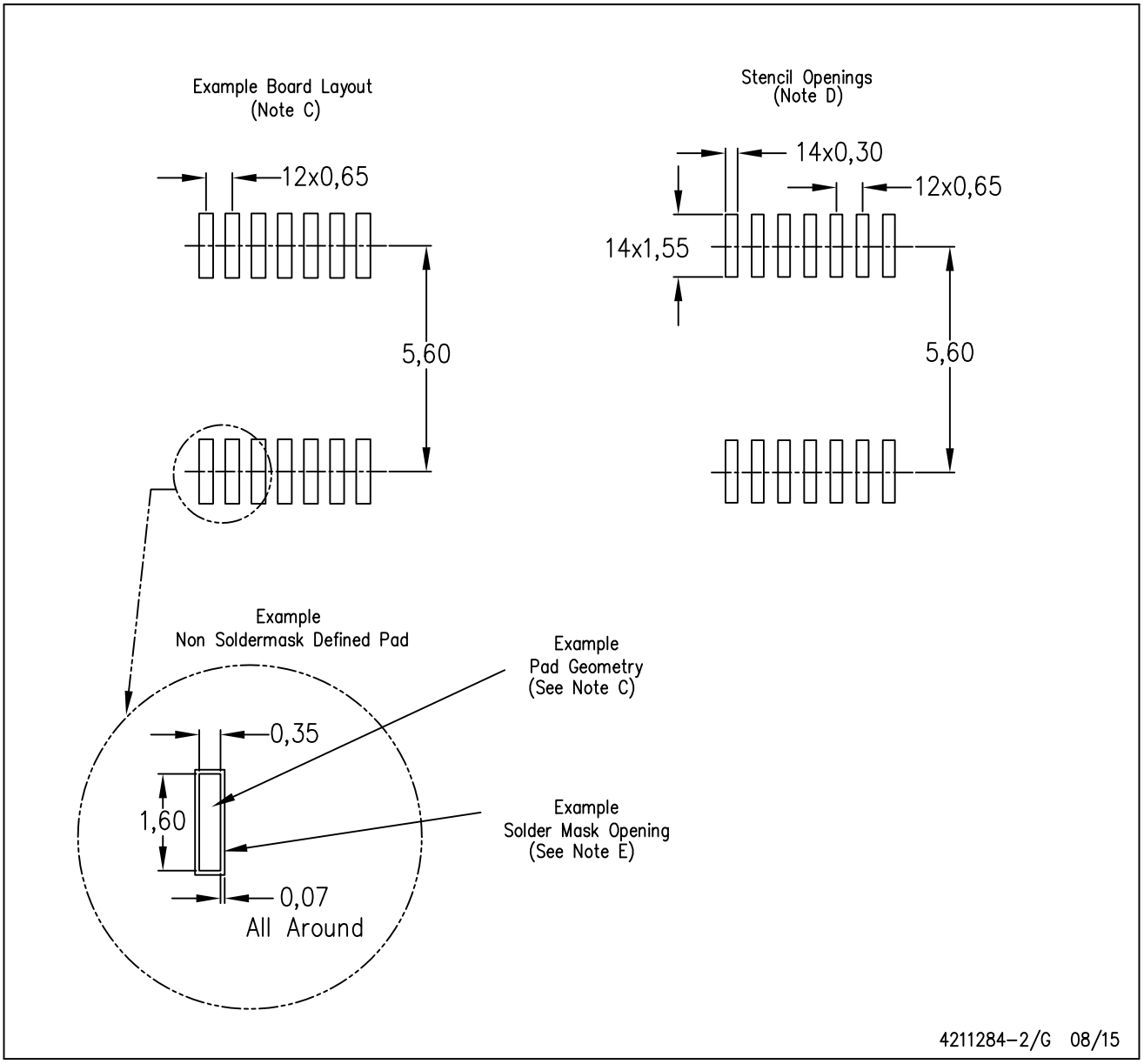
PW (R–PDSO–G14) PLASTIC SMALL OUTLINE




4040064–3/G 02/11

NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
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 each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
E. Falls within JEDEC MO–153

PW (R–PDSO–G14) 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 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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