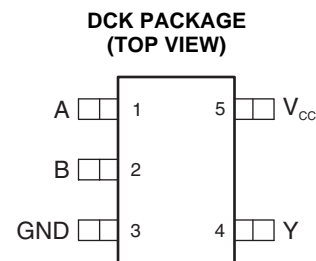


## LOW POWER, 1.8/2.5/3.3-V INPUT, 3.3-V CMOS OUTPUT, 2-INPUT EXCLUSIVE-NOR GATE

Check for Samples: [SN74AUP1T87](#)

### FEATURES

- **Single-Supply Voltage Translator**
- **Output Level Up to Supply  $V_{CC}$  CMOS Level**
  - 1.8 V to 3.3 V (at  $V_{CC} = 3.3$  V)
  - 2.5 V to 3.3 V (at  $V_{CC} = 3.3$  V)
  - 1.8 V to 2.5 V (at  $V_{CC} = 2.5$  V)
  - 3.3 V to 2.5 V (at  $V_{CC} = 2.5$  V)
- **Schmitt-Trigger Inputs Reject Input Noise and Provide Better Output Signal Integrity**
- **$I_{off}$  Supports Partial Power Down ( $V_{CC} = 0$  V)**
- **Very Low Static Power Consumption: 0.1  $\mu$ A**
- **Very Low Dynamic Power Consumption: 0.9  $\mu$ A**
- **Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II**
- **Pb-Free Packages Available: SC-70 (DCK) 2 x 2.1 x 0.65 mm (Height 1.1 mm)**
- **More Gate Options Available at [www.ti.com/littlelogic](http://www.ti.com/littlelogic)**
- **ESD Performance Tested Per JESD 22**
  - 2000-V Human-Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)



### DESCRIPTION/ORDERING INFORMATION

The SN74AUP1T87 performs the Boolean function  $Y = \overline{A \oplus B}$  with designation for logic-level translation applications with output referenced to supply  $V_{CC}$ .

AUP technology is the industry's lowest-power logic technology designed for use in extending battery-life in operating. All input levels that accept 1.8-V LVCMOS signals, while operating from either a single 3.3-V or 2.5-V  $V_{CC}$  supply. This product also maintains excellent signal integrity (see [Figure 1](#) and [Figure 2](#)).

The wide  $V_{CC}$  range of 2.3 V to 3.6 V allows the possibility of switching output level to connect to external controllers or processors.

Schmitt-trigger inputs ( $\Delta V_T = 210$  mV between positive and negative input transitions) offer improved noise immunity during switching transitions, which is especially useful on analog mixed-mode designs. Schmitt-trigger inputs reject input noise, ensure integrity of output signals, and allow for slow input signal transition.

$I_{off}$  is a feature that allows for powered-down conditions ( $V_{CC} = 0$  V) and is important in portable and mobile applications. When  $V_{CC} = 0$  V, signals in the range from 0 V to 3.6 V can be applied to the inputs and outputs of the device. No damage occurs to the device under these conditions.

The SN74AUP1T87 is designed with optimized current-drive capability of 4 mA to reduce line reflections, overshoot, and undershoot caused by high-drive outputs.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

**ORDERING INFORMATION<sup>(1)</sup>**

T <sub>A</sub>	PACKAGE <sup>(2)</sup>	ORDERABLE PART NUMBER	TOP-SIDE MARKING <sup>(3)</sup>
-40°C to 85°C	SOT (SC-70) – DCK	Reel of 3000	SN74AUP1T87DCKR
		Reel of 250	SN74AUP1T87DCKT

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).
- (2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).
- (3) The actual top-side marking has one additional character that designates the wafer fab/assembly site.

**FUNCTION TABLE**

INPUTS (Lower Level Input)		OUTPUT (V <sub>CC</sub> CMOS)
A	B	Y
L	L	H
L	H	L
H	L	L
H	H	H

**Supply V<sub>CC</sub> = 2.3 V to 2.7 V (2.5 V)**

INPUTS V <sub>T+</sub> max = V <sub>IH</sub> min V <sub>T-</sub> min = V <sub>IL</sub> max		OUTPUT CMOS
A	B	Y
V <sub>IH</sub> = 1.1 V		V <sub>OH</sub> = 1.85 V
V <sub>IL</sub> = 0.35 V		V <sub>OL</sub> = 0.45 V

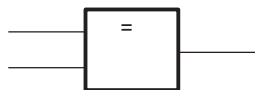
**Supply V<sub>CC</sub> = 3 V to 3.6 V (3.3 V)**

INPUTS V <sub>T+</sub> max = V <sub>IH</sub> min V <sub>T-</sub> min = V <sub>IL</sub> max		OUTPUT CMOS
A	B	Y
V <sub>IH</sub> = 1.19 V		V <sub>OH</sub> = 2.55 V
V <sub>IL</sub> = 0.5 V		V <sub>OL</sub> = 0.45 V

**LOGIC DIAGRAM (XNOR GATE)**

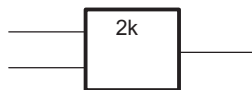


**LOGIC-IDENTITY ELEMENT**



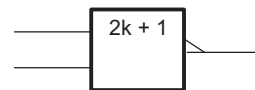
The output is active (high) if all inputs stand at the same logic level (i.e., A = B).

**EVEN-PARITY ELEMENT**



The output is active (high) if an even number of inputs (i.e., 0 or 2) are active.

**ODD-PARITY ELEMENT**



The output is active (low) if an odd number of inputs (i.e., only 1 of the 2) are active.

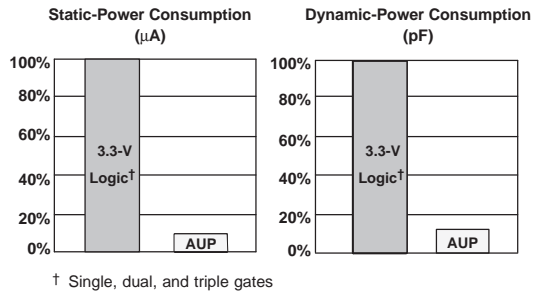


Figure 1. AUP – The Lowest-Power Family

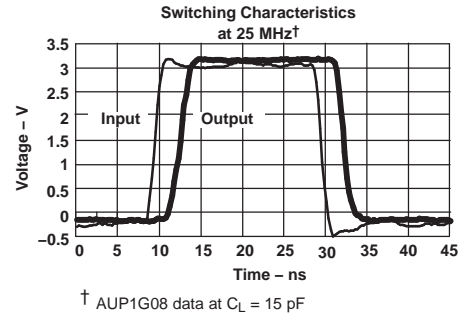


Figure 2. Excellent Signal Integrity

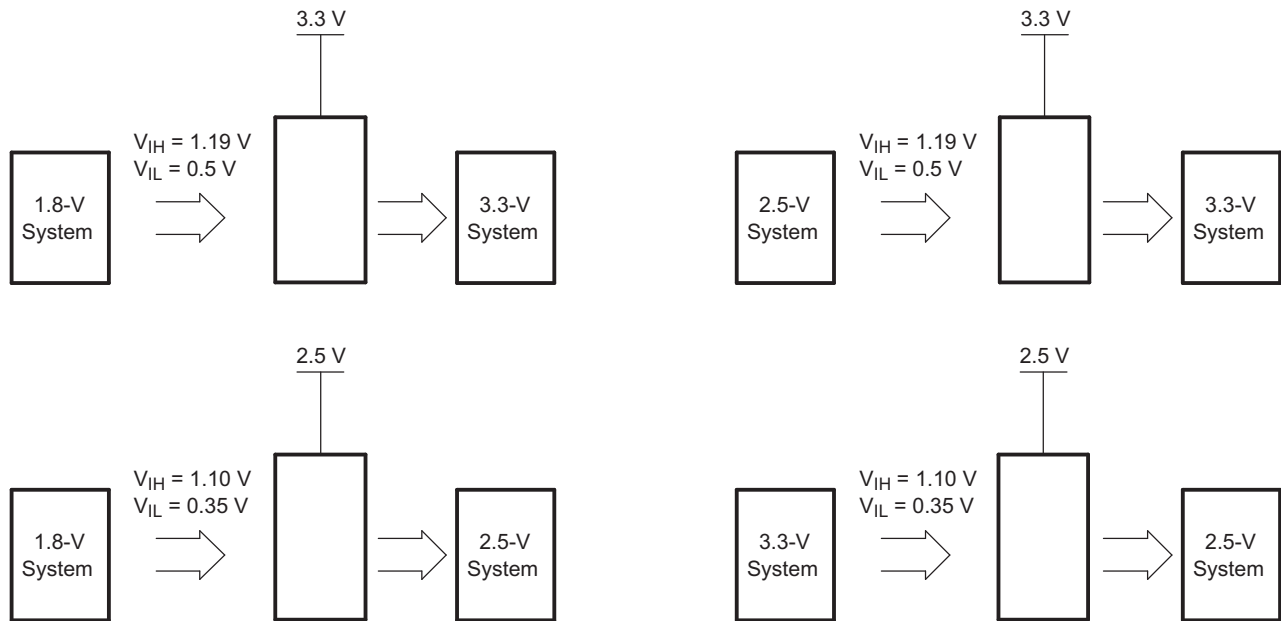


Figure 3. Typical Design Examples

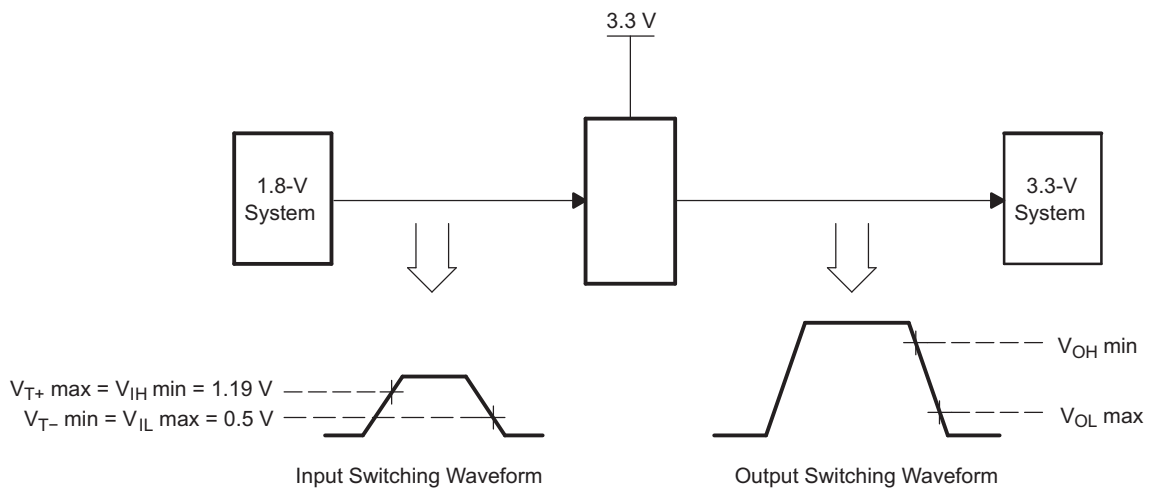


Figure 4. Switching Thresholds for 1.8-V to 3.3-V Translation

**ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>**

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

			MIN	MAX	UNIT
$V_{CC}$	Supply voltage range		-0.5	4.6	V
$V_I$	Input voltage range <sup>(2)</sup>		-0.5	4.6	V
$V_O$	Voltage range applied to any output in the high-impedance or power-off state <sup>(2)</sup>		-0.5	4.6	V
$V_O$	Output voltage range in the high or low state <sup>(2)</sup>		-0.5	$V_{CC} + 0.5$	V
$I_{IK}$	Input clamp current	$V_I < 0$		-50	mA
$I_{OK}$	Output clamp current	$V_O < 0$		-50	mA
$I_O$	Continuous output current			$\pm 20$	mA
	Continuous current through $V_{CC}$ or GND			$\pm 50$	mA
$\theta_{JA}$	Package thermal impedance <sup>(3)</sup>	DCK package		259	°C/W
$T_{stg}$	Storage temperature range		-65	150	°C

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.
- (3) The package thermal impedance is calculated in accordance with JESD 51-7.

**RECOMMENDED OPERATING CONDITIONS<sup>(1)</sup>**

			MIN	MAX	UNIT
$V_{CC}$	Supply voltage		2.3	3.6	V
$V_I$	Input voltage		0	3.6	V
$V_O$	Output voltage		0	$V_{CC}$	V
$I_{OH}$	High-level output current	$V_{CC} = 2.3\text{ V}$		-3.1	mA
		$V_{CC} = 3\text{ V}$		-4	
$I_{OL}$	Low-level output current	$V_{CC} = 2.3\text{ V}$		3.1	mA
		$V_{CC} = 3\text{ V}$		4	
$T_A$	Operating free-air temperature		-40	85	°C

- (1) All unused inputs of the device must be held at  $V_{CC}$  or GND to ensure proper device operation. See the TI application report *Implications of Slow or Floating CMOS Inputs*, literature number [SCBA004](#).

## ELECTRICAL CHARACTERISTICS

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

PARAMETER	TEST CONDITIONS	V <sub>CC</sub>	T <sub>A</sub> = 25°C			T <sub>A</sub> = -40°C to 85°C		UNIT
			MIN	TYP	MAX	MIN	MAX	
V <sub>T+</sub> Positive-going input threshold voltage		2.3 V to 2.7 V	0.6	1.1		0.6	1.1	V
		3 V to 3.6 V	0.75	1.16		0.75	1.19	
V <sub>T-</sub> Negative-going input threshold voltage		2.3 V to 2.7 V	0.35	0.6		0.35	0.6	V
		3 V to 3.6 V	0.5	0.85		0.5	0.85	
ΔV <sub>T</sub> Hysteresis (V <sub>T+</sub> - V <sub>T-</sub> )		2.3 V to 2.7 V	0.23	0.6		0.1	0.6	V
		3 V to 3.6 V	0.25	0.56		0.15	0.56	
V <sub>OH</sub>	I <sub>OH</sub> = -20 μA	2.3 V to 3.6 V	V <sub>CC</sub> - 0.1			V <sub>CC</sub> - 0.1		V
	I <sub>OH</sub> = -2.3 mA	2.3 V	2.05			1.97		
	I <sub>OH</sub> = -3.1 mA		1.9			1.85		
	I <sub>OH</sub> = -2.7 mA	3 V	2.72			2.67		
	I <sub>OH</sub> = -4 mA		2.6			2.55		
V <sub>OL</sub>	I <sub>OL</sub> = 20 μA	2.3 V to 3.6 V				0.1	0.1	V
	I <sub>OL</sub> = 2.3 mA	2.3 V				0.31	0.33	
	I <sub>OL</sub> = 3.1 mA					0.44	0.45	
	I <sub>OL</sub> = 2.7 mA	3 V				0.31	0.33	
	I <sub>OL</sub> = 4 mA					0.44	0.45	
I <sub>I</sub>	All inputs	V <sub>I</sub> = 3.6 V or GND	0 V to 3.6 V			0.1	0.5	μA
I <sub>off</sub>		V <sub>I</sub> or V <sub>O</sub> = 0 V to 3.6 V	0 V			0.1	0.5	μA
ΔI <sub>off</sub>		V <sub>I</sub> or V <sub>O</sub> = 3.6 V	0 V to 0.2 V			0.2	0.5	μA
I <sub>CC</sub>		V <sub>I</sub> = 3.6 V or GND, I <sub>O</sub> = 0	2.3 V to 3.6 V			0.5	0.9	μA
ΔI <sub>CC</sub>		One input at 0.3 V or 1.1 V, Other inputs at 0 or V <sub>CC</sub> , I <sub>O</sub> = 0	2.3 V to 2.7 V				4	μA
		One input at 0.45 V or 1.2 V, Other inputs at 0 or V <sub>CC</sub> , I <sub>O</sub> = 0	3 V to 3.6 V				12	
C <sub>i</sub>		V <sub>I</sub> = V <sub>CC</sub> or GND	3.3 V			1.5		pF
C <sub>o</sub>		V <sub>O</sub> = V <sub>CC</sub> or GND	3.3 V			3		pF

## SWITCHING CHARACTERISTICS

over recommended operating free-air temperature range, V<sub>CC</sub> = 2.5 V ± 0.2 V, V<sub>I</sub> = 1.8 V ± 0.15 V (unless otherwise noted) (see Figure 5)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	C <sub>L</sub>	T <sub>A</sub> = 25°C			T <sub>A</sub> = -40°C to 85°C		UNIT
				MIN	TYP	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	Y	5 pF	1.8	2.3	2.9	0.5	6.8	ns
			10 pF	2.3	2.8	3.4	1	7.9	
			15 pF	2.6	3.1	3.8	1	8.7	
			30 pF	3.8	4.4	5.1	1.5	10.8	

### SWITCHING CHARACTERISTICS

over recommended operating free-air temperature range,  $V_{CC} = 2.5\text{ V} \pm 0.2\text{ V}$ ,  $V_I = 2.5\text{ V} \pm 0.2\text{ V}$  (unless otherwise noted) (see [Figure 5](#))

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$C_L$	$T_A = 25^\circ\text{C}$			$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$		UNIT
				MIN	TYP	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	5 pF	1.8	2.3	3.1	0.5	6	ns
			10 pF	2.2	2.8	3.5	1	7.1	
			15 pF	2.6	3.2	5.2	1	7.9	
			30 pF	3.7	4.4	5.2	1.5	10	

### SWITCHING CHARACTERISTICS

over recommended operating free-air temperature range,  $V_{CC} = 2.5\text{ V} \pm 0.2\text{ V}$ ,  $V_I = 3.3\text{ V} \pm 0.3\text{ V}$  (unless otherwise noted) (see [Figure 5](#))

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$C_L$	$T_A = 25^\circ\text{C}$			$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$		UNIT
				MIN	TYP	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	5 pF	2	2.7	3.5	0.5	5.5	ns
			10 pF	2.4	3.1	3.9	1	6.5	
			15 pF	2.8	3.5	4.3	1	7.4	
			30 pF	4	4.7	5.5	1.5	9.5	

### SWITCHING CHARACTERISTICS

over recommended operating free-air temperature range,  $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ ,  $V_I = 1.8\text{ V} \pm 0.15\text{ V}$  (unless otherwise noted) (see [Figure 5](#))

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$C_L$	$T_A = 25^\circ\text{C}$			$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$		UNIT
				MIN	TYP	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	5 pF	1.6	2	2.5	0.5	8	ns
			10 pF	2	2.4	2.9	1	8.5	
			15 pF	2.3	2.8	3.3	1	9.1	
			30 pF	3.4	3.9	4.4	1.5	9.8	

### SWITCHING CHARACTERISTICS

over recommended operating free-air temperature range,  $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ ,  $V_I = 2.5\text{ V} \pm 0.2\text{ V}$  (unless otherwise noted) (see [Figure 5](#))

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$C_L$	$T_A = 25^\circ\text{C}$			$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$		UNIT
				MIN	TYP	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	5 pF	1.6	1.9	2.4	0.5	5.3	ns
			10 pF	2	2.3	2.7	1	6.1	
			15 pF	2.3	2.7	3.1	1	6.8	
			30 pF	3.4	3.8	4.2	1.5	8.5	

## SWITCHING CHARACTERISTICS

over recommended operating free-air temperature range,  $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ ,  $V_I = 3.3\text{ V} \pm 0.3\text{ V}$  (unless otherwise noted) (see [Figure 5](#))

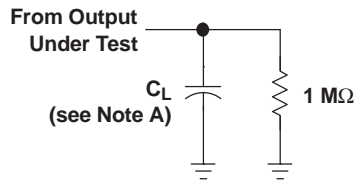
PARAMETER	FROM (INPUT)	TO (OUTPUT)	$C_L$	$T_A = 25^\circ\text{C}$			$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$		UNIT
				MIN	TYP	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	5 pF	1.6	2.1	2.7	0.5	4.7	ns
			10 pF	2	2.4	3	1	5.7	
			15 pF	2.3	2.7	3.3	1	6.2	
			30 pF	3.4	3.8	4.4	1.5	7.8	

## OPERATING CHARACTERISTICS

$T_A = 25^\circ\text{C}$

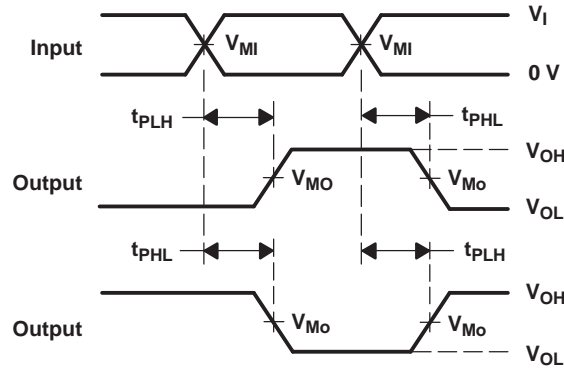
PARAMETER		TEST CONDITIONS	$V_{CC} = 2.5\text{ V}$	$V_{CC} = 3.3\text{ V}$	UNIT
			TYP	TYP	
$C_{pd}$	Power dissipation capacitance	$f = 10\text{ MHz}$	4	5	pF

**PARAMETER MEASUREMENT INFORMATION**



	$V_{CC} = 2.5\text{ V}$ $\pm 0.2\text{ V}$	$V_{CC} = 3.3\text{ V}$ $\pm 0.3\text{ V}$
$C_L$	5, 10, 15, 30 pF	5, 10, 15, 30 pF
$V_{MI}$	$V_I/2$	$V_I/2$
$V_{MO}$	$V_{CC}/2$	$V_{CC}/2$

**LOAD CIRCUIT**



**VOLTAGE WAVEFORMS  
PROPAGATION DELAY TIMES  
INVERTING AND NONINVERTING OUTPUTS**

- NOTES: A.  $C_L$  includes probe and jig capacitance.  
 B. All input pulses are supplied by generators having the following characteristics: PRR  $\leq 10$  MHz,  $Z_O = 50\ \Omega$ , slew rate  $\geq 1$  V/ns.  
 C. The outputs are measured one at a time, with one transition per measurement.  
 D.  $t_{PLH}$  and  $t_{PHL}$  are the same as  $t_{pd}$ .

**Figure 5. Load Circuit and Voltage Waveforms**



**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
SN74AUP1T87DCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	(6J5 ~ 6JF)	<a href="#">Samples</a>

(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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side 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 Top-Side Marking for that device.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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## TAPE AND REEL INFORMATION



### 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
SN74AUP1T87DCKR	SC70	DCK	5	3000	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
SN74AUP1T87DCKR	SC70	DCK	5	3000	178.0	9.2	2.4	2.4	1.22	4.0	8.0	Q3

**TAPE AND REEL BOX DIMENSIONS**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74AUP1T87DCKR	SC70	DCK	5	3000	180.0	180.0	18.0
SN74AUP1T87DCKR	SC70	DCK	5	3000	180.0	180.0	18.0

DCK (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



- 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.

DCK (R-PDSO-G5)

PLASTIC SMALL OUTLINE



- 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.

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