

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 μ A**
- **Very Low Dynamic Power Consumption: 0.9 μ 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**
- **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⁽¹⁾

T _A	PACKAGE ⁽²⁾	ORDERABLE PART NUMBER	TOP-SIDE MARKING ⁽³⁾
-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.
- (2) Package drawings, thermal data, and symbolization are available at 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 _{CC} CMOS)
A	B	Y
L	L	H
L	H	L
H	L	L
H	H	H

Supply V_{CC} = 2.3 V to 2.7 V (2.5 V)

INPUTS V _{T+} max = V _{IH} min V _{T-} min = V _{IL} max		OUTPUT CMOS
A	B	Y
V _{IH} = 1.1 V		V _{OH} = 1.85 V
V _{IL} = 0.35 V		V _{OL} = 0.45 V

Supply V_{CC} = 3 V to 3.6 V (3.3 V)

INPUTS V _{T+} max = V _{IH} min V _{T-} min = V _{IL} max		OUTPUT CMOS
A	B	Y
V _{IH} = 1.19 V		V _{OH} = 2.55 V
V _{IL} = 0.5 V		V _{OL} = 0.45 V

LOGIC DIAGRAM (XNOR GATE)

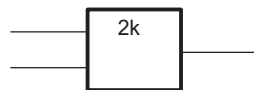


LOGIC-IDENTITY ELEMENT



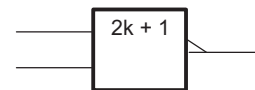
The output is active (high) if all inputs stand at the same logic level (i.e., A = B).

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.

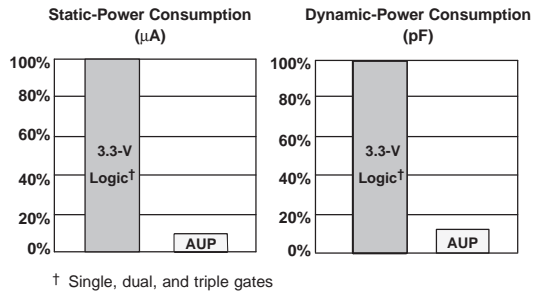


Figure 1. AUP – The Lowest-Power Family

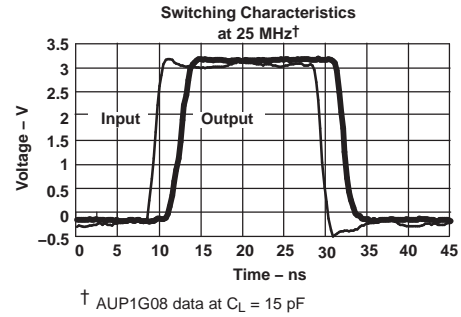


Figure 2. Excellent Signal Integrity

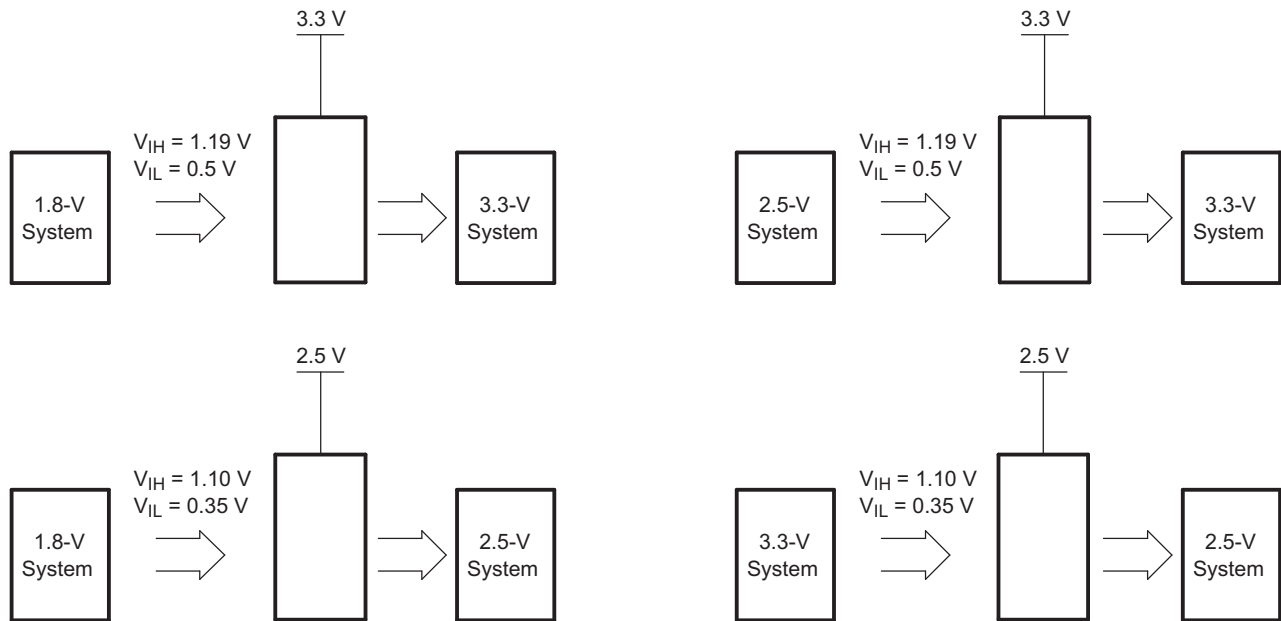


Figure 3. Typical Design Examples

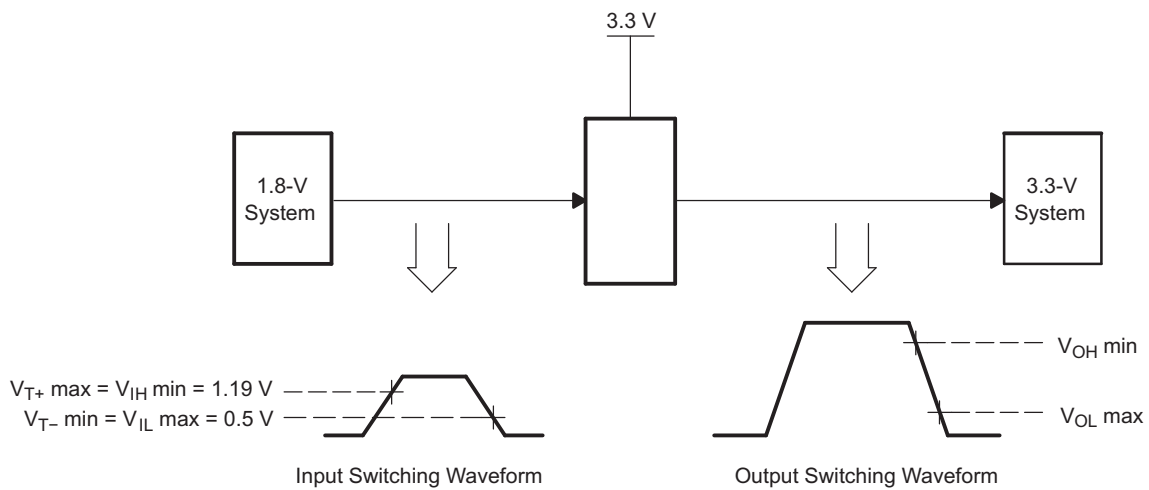


Figure 4. Switching Thresholds for 1.8-V to 3.3-V Translation

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

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 ⁽²⁾		-0.5	4.6	V
V_O	Voltage range applied to any output in the high-impedance or power-off state ⁽²⁾		-0.5	4.6	V
V_O	Output voltage range in the high or low state ⁽²⁾		-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			± 20	mA
	Continuous current through V_{CC} or GND			± 50	mA
θ_{JA}	Package thermal impedance ⁽³⁾	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⁽¹⁾

			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 _{CC}	T _A = 25°C			T _A = -40°C to 85°C		UNIT
			MIN	TYP	MAX	MIN	MAX	
V _{T+} 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 _{T-} 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 _T Hysteresis (V _{T+} - V _{T-})		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 _{OH}	I _{OH} = -20 μA	2.3 V to 3.6 V	V _{CC} - 0.1			V _{CC} - 0.1		V
	I _{OH} = -2.3 mA	2.3 V	2.05			1.97		
	I _{OH} = -3.1 mA		1.9			1.85		
	I _{OH} = -2.7 mA	3 V	2.72			2.67		
	I _{OH} = -4 mA		2.6			2.55		
V _{OL}	I _{OL} = 20 μA	2.3 V to 3.6 V				0.1	0.1	V
	I _{OL} = 2.3 mA	2.3 V				0.31	0.33	
	I _{OL} = 3.1 mA					0.44	0.45	
	I _{OL} = 2.7 mA	3 V				0.31	0.33	
	I _{OL} = 4 mA					0.44	0.45	
I _I	All inputs	V _I = 3.6 V or GND	0 V to 3.6 V			0.1	0.5	μA
I _{off}		V _I or V _O = 0 V to 3.6 V	0 V			0.1	0.5	μA
ΔI _{off}		V _I or V _O = 3.6 V	0 V to 0.2 V			0.2	0.5	μA
I _{CC}		V _I = 3.6 V or GND, I _O = 0	2.3 V to 3.6 V			0.5	0.9	μA
ΔI _{CC}		One input at 0.3 V or 1.1 V, Other inputs at 0 or V _{CC} , I _O = 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 _{CC} , I _O = 0	3 V to 3.6 V				12	
C _i		V _I = V _{CC} or GND	3.3 V			1.5		pF
C _o		V _O = V _{CC} or GND	3.3 V			3		pF

SWITCHING CHARACTERISTICS

over recommended operating free-air temperature range, V_{CC} = 2.5 V ± 0.2 V, V_I = 1.8 V ± 0.15 V (unless otherwise noted) (see Figure 5)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	C _L	T _A = 25°C			T _A = -40°C to 85°C		UNIT
				MIN	TYP	MAX	MIN	MAX	
t _{pd}	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°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°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°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°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](#))

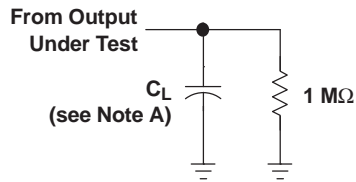
PARAMETER	FROM (INPUT)	TO (OUTPUT)	C_L	$T_A = 25^\circ\text{C}$			$T_A = -40^\circ\text{C}$ to 85°C		UNIT
				MIN	TYP	MAX	MIN	MAX	
t_{pd}	A or B	Y	5 pF	1.6	2.1	2.7	0.5	4.7	ns
			10 pF	2	2.4	3	1	5.7	
			15 pF	2.3	2.7	3.3	1	6.2	
			30 pF	3.4	3.8	4.4	1.5	7.8	

OPERATING CHARACTERISTICS

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

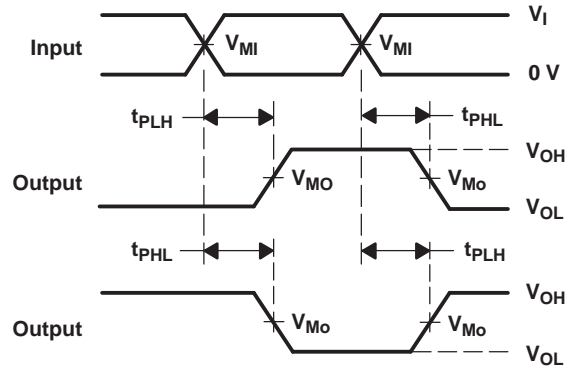
PARAMETER	TEST CONDITIONS	$V_{CC} = 2.5\text{ V}$	$V_{CC} = 3.3\text{ V}$	UNIT
		TYP	TYP	
C_{pd} Power dissipation capacitance	$f = 10\text{ MHz}$	4	5	pF

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 ≤ 10 MHz, $Z_O = 50\ \Omega$, slew rate ≥ 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 (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN74AUP1T87DCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 85	(6J5, 6JF)	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/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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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	9.2	2.4	2.4	1.22	4.0	8.0	Q3
SN74AUP1T87DCKR	SC70	DCK	5	3000	178.0	9.0	2.4	2.5	1.2	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:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
 - Publication IPC-7351 is recommended for alternate designs.
 - 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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