







CD74HCT86, CD54HCT86

SCHS410A - JUNE 2020 - REVISED AUGUST 2024

CDx4HCT86 Quadruple 2-Input XOR Gates

1 Features

- LSTTL input logic compatible
 - $V_{IL(max)} = 0.8V, V_{IH(min)} = 2V$
- CMOS input logic compatible
 - I_I ≤ 1μA at V_{OL}, V_{OH}
- **Buffered inputs**
- 4.5V to 5.5V operation
- Wide operating temperature range: -55°C to +125°C
- Supports fanout up to 10 LSTTL loads
- Significant power reduction compared to LSTTL logic ICs

2 Applications

- Detect phase differences in input signals
- Create a selectable inverter / buffer

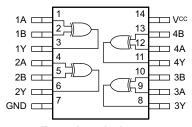
3 Description

This device contains four independent 2-input XOR gates. Each gate performs the Boolean function $Y = A \oplus B$ in positive logic.

Device Information

PART NUMBER	PACKAGE ⁽¹⁾	PACKAGE SIZE(2)	BODY SIZE(3)
	D (SOIC, 14)	8.65mm × 6mm	8.65mm × 3.9mm
CDx4HCT86	N (PDIP, 14)	19.30mm × 9.4mm	19.30mm × 6.35mm
	J (CDIP, 14)	19.56mm x 6.7mm	19.56mm × 4.57mm

- For more information, see Mechanical, Packaging, and Orderable Information.
- The package size (length × width) is a nominal value and includes pins, where applicable.
- The body size (length × width) is a nominal value and does not include pins.



Functional pinout



Table of Contents

1 Features	1	7.3 Feature Description	8
2 Applications		7.4 Device Functional Modes	
3 Description		8 Application and Implementation	10
4 Pin Configuration and Functions	3	8.1 Application Information	10
5 Specifications	4	8.2 Typical Application	
5.1 Absolute Maximum Ratings	4	8.3 Power Supply Recommendations	11
5.2 ESD Ratings		8.4 Layout	11
5.3 Recommended Operating Conditions	4	9 Device and Documentation Support	13
5.4 Thermal Information	4	9.1 Documentation Support	13
5.5 Electrical Characteristics	5	9.2 Receiving Notification of Documentation Updates	13
5.6 Switching Characteristics	5	9.3 Support Resources	13
5.7 Operating Characteristics		9.4 Trademarks	13
5.8 Typical Characteristics	6	9.5 Electrostatic Discharge Caution	13
6 Parameter Measurement Information	7	9.6 Glossary	13
7 Detailed Description	8	10 Revision History	13
7.1 Overview		11 Mechanical, Packaging, and Orderable	
7.2 Functional Block Diagram		Information	13
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4 Pin Configuration and Functions

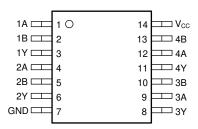


Figure 4-1. D, N, or J Package 14-Pin SOIC, PDIP, or CDIP Top View

	PIN		DESCRIPTION				
NAME	NO.	ITPE\"	DESCRIPTION				
1A	1	Input	Channel 1, Input A				
1B	2	Input	Channel 1, Input B				
1Y	3	Output	Channel 1, Output Y				
2A	4	Input	Channel 2, Input A				
2B	5	Input	Channel 2, Input B				
2Y	6	Output	Channel 2, Output Y				
GND	7	_	Ground				
3Y	8	Output	Channel 3, Output Y				
3A	9	Input	Channel 3, Input A				
3B	10	Input	Channel 3, Input B				
4Y	11	Output	Channel 4, Output Y				
4A	12	Input	Channel 4, Input A				
4B	13	Input	Channel 4, Input B				
V _{CC}	14	_	Positive Supply				

⁽¹⁾ Signal Types: I = Input, O = Output, I/O = Input or Output



5 Specifications

5.1 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⁾	$V_1 < -0.5 \text{ V or } V_1 > V_{CC} + 0.5 \text{ V}$		±20	mA
I _{OK}	Output clamp current ⁽²⁾		±20	mA	
Io	Continuous output current	$V_{O} > -0.5 \text{ V or } V_{O} < V_{CC} + 0.5 \text{ V}$		±25	mA
	Continuous current through V _{CC} or GND	·		±50	mA
TJ	Junction temperature ⁽³⁾			150	°C
	Lead temperature (soldering 10s)	SOIC - lead tips only		300	°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.

5.2 ESD Ratings

			VALUE	UNIT
V	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/ JEDEC JS-001 ⁽¹⁾	±2000	V
V(ESD)	Electrostatic discharge	Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	±1000	V

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

5.3 Recommended Operating Conditions

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

			MIN	NOM	MAX	UNIT
V _{CC}	Supply voltage		4.5		5.5	V
V _{IH}	High-level input voltage	V _{CC} = 4.5 V to 5.5 V	2			V
V _{IL}	Low-level input voltage	V _{CC} = 4.5 V to 5.5 V			8.0	V
VI	Input voltage		0		V _{CC}	V
Vo	Output voltage		0		V _{CC}	V
	Input transition time	V _{CC} = 4.5 V			500	ns
l ^t t	input transition time	V _{CC} = 5.5 V			400	113
T _A	Operating free-air temperature		– 55		125	°C

5.4 Thermal Information

		CD74	CD74HCT86					
THERMAL METRIC(1)		THERMAL METRIC ⁽¹⁾ N (PDIP)						
		14 PINS	14 PINS					
$R_{\theta JA}$	Junction-to-ambient thermal resistance	103.8	138.7	°C/W				
R _{0JC(top)}	Junction-to-case (top) thermal resistance	91.6	93.8	°C/W				
$R_{\theta JB}$	Junction-to-board thermal resistance	83.5	94.7	°C/W				

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⁽²⁾ The input and output voltage ratings may be exceeded if the input and output current ratings are observed.

⁽³⁾ Guaranteed by design.

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

		CD74I		
	THERMAL METRIC ⁽¹⁾	N (PDIP)	D (SOIC)	UNIT
		14 PINS	14 PINS	
Ψ_{JT}	Junction-to-top characterization parameter	71.1	49.1	°C/W
Ψ _{JB} Junction-to-board characterization parameter		83.4	94.3	°C/W
R _{0JC(bot)} Junction-to-case (bottom) thermal resistance		N/A	N/A	°C/W

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

5.5 Electrical Characteristics

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

			TEST CONDITIONS				Operat	ing free	air ten	peratu	re (T _A)			
	PARAMETER	TEST COND				25°C		–40°	C to 85	s°C	-55°(C to 12	5°C	UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{OH}	High-level output	V _I = V _{IH} or	I _{OH} = -20 μΑ	4.5 V	4.4			4.4	-		4.4			V
	voltage V _{IL}	VIL.	I _{OH} = -4 mA	4.5 V	3.98			3.84			3.7			
V _{OL}	Low-level output $V_I = V_{IH}$ or		I _{OL} = 20 μA	4.5 V			0.1			0.1			0.1	V
VOL	voltage	V _{IL}	I _{OL} = 4 mA	4.5 V			0.26			0.33			0.4	V
I _I	Input leakage current	V _I = V _{CC} and GND	I _O = 0	5.5 V			±0.1			±1			±1	μΑ
I _{CC}	Supply current	V _I = V _{CC} or GND	I _O = 0	5.5 V			2			20			40	μΑ
ΔI _{CC} (1)	Additional Quiescent Device Current Per Input Pin.	V _I = V _{CC} - 2.1		4.5 V to 5.5 V		100	360			450			490	μA
Ci	Input capacitance			5 V			10			10			10	pF

⁽¹⁾ For dual-supply systems theoretical worst case (V_I = 2.4 V, V_{CC} = 5.5 V) specification is 1.8 mA.

5.6 Switching Characteristics

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

				TEST	rest		Operating free-air temperature (T _A)								
	PARAMETER	FROM	то	CONDITIO	V _{cc}	25°C			-40°C to 85°C		5°C	-55°C to 125°C		UNIT	
				NS		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
	Propagation delay	A or B	Υ	C _L = 50 pF	4.5 V			32			40			48	ns
^L pd	Propagation delay	A or B	Υ	C _L = 15 pF	5 V		13								115
t _t	Transition-time		Υ	C _L = 50 pF	4.5 V			15			19			22	ns

5.7 Operating Characteristics

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

	PARAMETER	TEST CONDITIONS	V _{CC}	MIN	TYP MAX	UNIT
C _{pd}	Power dissipation capacitance per gate	No load	5 V		27	pF

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5.8 Typical Characteristics

 $T_A = 25^{\circ}C$

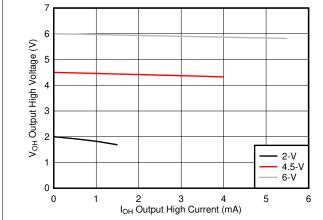


Figure 5-1. Typical output voltage in the high state (V_{OH})

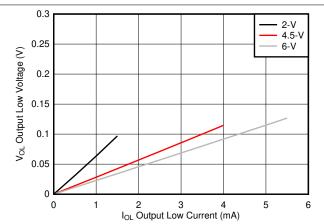
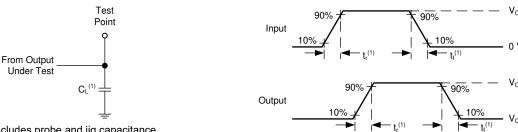


Figure 5-2. Typical output voltage in the low state (V_{OL})



6 Parameter Measurement Information

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

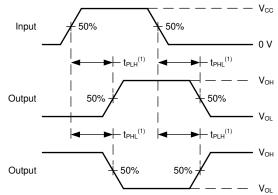


A. C_L = 50 pF and includes probe and jig capacitance.

Figure 6-1. Load Circuit

A. t_t is the greater of t_r and t_f .

Figure 6-2. Voltage Waveforms Transition Times



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

Figure 6-3. Voltage Waveforms Propagation Delays

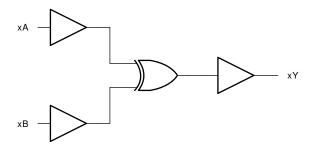


7 Detailed Description

7.1 Overview

This device contains four independent 2-input XOR gates. Each gate performs the Boolean function $Y = A \oplus B$ in positive logic.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 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 Section 5.1 must be followed at all times.

The CD74HCT86 can drive a load with a total capacitance less than or equal to the maximum load listed in the Section 5.6 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 the provided load value. 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 Section 5.1.

7.3.2 TTL-Compatible CMOS Inputs

TTL-Compatible 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 Section 5.5. The worst case resistance is calculated with the maximum input voltage, given in the Section 5.1, and the maximum input leakage current, given in the Section 5.5, 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 Section 5.3 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 TTL-compatible CMOS input.

TTL-Compatible CMOS inputs have a lower threshold voltage than standard CMOS inputs to allow for compatibility with older bipolar logic devices. See the Section 5.3 for the valid input voltages for the CD74HCT86.



7.3.3 Clamp Diode Structure

The inputs and outputs to this device have both positive and negative clamping diodes as depicted in Figure 7-1.

CAUTION

Voltages beyond the values specified in the Section 5.1 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.

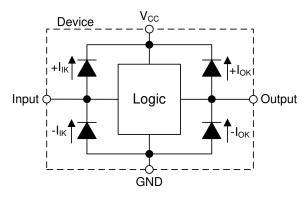


Figure 7-1. Electrical Placement of Clamping Diodes for Each Input and Output

7.4 Device Functional Modes

Table 7-1. Function Table

INPU	ITS ⁽¹⁾	OUTPUT ⁽²⁾
Α	В	Y
L	L	L
L	Н	Н
Н	L	Н
Н	Н	L

- (1) H = High Voltage Level, L = Low Voltage Level, X = Don't Care
- (2) H = Driving High, L = Driving Low, Z = High Impedance State

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, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

In this application, a 2-input XOR gate is used as a phase difference detector as shown in *Figure 8-1*. The remaining three gates can be used for other applications in the system, or the inputs can be grounded and the channels left unused.

The device is used to identify phase difference between a reference clock and another input clock. Whenever the clock states are different, the XOR output will pulse HIGH until the clocks return to the same state. The output is fed into a low-pass filter to obtain a DC representation of the phase difference.

8.2 Typical Application

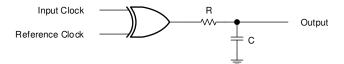


Figure 8-1. Typical application schematic

8.2.1 Design Requirements

8.2.1.1 Power Considerations

Ensure the desired supply voltage is within the range specified in the Section 5.3. The supply voltage sets the device's electrical characteristics as described in the Section 5.5.

The supply must be capable of sourcing current equal to the total current to be sourced by all outputs of the CD74HCT86 plus the maximum supply current, I_{CC} , listed in the Section 5.5. 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 Section 5.1.

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 Section 5.1, is an additional limitation to prevent damage to the device. Do not violate any values listed in the Section 5.1. These limits are provided to prevent damage to the device.

8.2.1.2 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 CD74HCT86, as specified in the Section 5.5, and the desired input transition rate. A 10-k Ω resistor value is often used due to these factors.

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Refer to the Section 7.3 for additional information regarding the inputs for this device.

8.2.1.3 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 Section 5.5 . 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_{OH} specification in the Section 5.5 .

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

Refer to Section 7.3 for additional information regarding the outputs for this device.

8.2.2 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 Section 8.4.
- 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 CD74HCT86
 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 *Section 5.1* 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

8.2.3 Application Curves



Figure 8-2. Typical application timing diagram

8.3 Power Supply Recommendations

The power supply can be any voltage between the minimum and maximum supply voltage rating located in the Section 5.3 . Each V_{CC} terminal should have a bypass capacitor to prevent power disturbance. A 0.1- μ F capacitor is recommended for this device. It is acceptable to parallel multiple bypass caps to reject different frequencies of noise. The 0.1- μ F and 1- μ F 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 Figure 8-3 .

8.4 Layout

8.4.1 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.



8.4.2 Layout Example

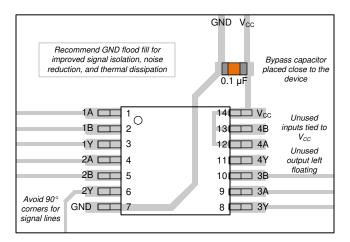


Figure 8-3. Example layout for the CD74HCT86



9 Device and Documentation Support

9.1 Documentation Support

9.1.1 Related Documentation

For related documentation see the following:

- HCMOS Design Considerations
- CMOS Power Consumption and CPD Calculation
- · Designing with Logic

9.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* 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.

9.3 Support Resources

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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9.4 Trademarks

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9.5 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.

9.6 Glossary

TI Glossary

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

10 Revision History

11 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.

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PACKAGING INFORMATION

Orderable Device	Status	Package Type	Package Drawing	Pins	Package Qty	Eco Plan	Lead finish/ Ball material	MSL Peak Temp	Op Temp (°C)	Device Marking (4/5)	Samples
5962-8984401CA	ACTIVE	CDIP	J	14	25	Non-RoHS & Green	(6) SNPB	N / A for Pkg Type	-55 to 125	5962-8984401CA CD54HCT86F3A	Samples
CD54HCT86F	ACTIVE	CDIP	J	14	25	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	CD54HCT86F	Samples
CD54HCT86F3A	ACTIVE	CDIP	J	14	25	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962-8984401CA CD54HCT86F3A	Samples
CD74HCT86E	ACTIVE	PDIP	N	14	25	RoHS & Green	NIPDAU	N / A for Pkg Type	-55 to 125	CD74HCT86E	Samples
CD74HCT86EE4	ACTIVE	PDIP	N	14	25	RoHS & Green	NIPDAU	N / A for Pkg Type	-55 to 125	CD74HCT86E	Samples
CD74HCT86M	OBSOLETE	SOIC	D	14		TBD	Call TI	Call TI	-55 to 125	HCT86M	
CD74HCT86M96	ACTIVE	SOIC	D	14	2500	RoHS & Green	NIPDAU SN	Level-1-260C-UNLIM	-55 to 125	HCT86M	Samples
CD74HCT86MT	OBSOLETE	SOIC	D	14		TBD	Call TI	Call TI	-55 to 125	HCT86M	

⁽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.

PACKAGE OPTION ADDENDUM

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(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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OTHER QUALIFIED VERSIONS OF CD54HCT86, CD74HCT86:

Catalog: CD74HCT86

Military: CD54HCT86

NOTE: Qualified Version Definitions:

- Catalog TI's standard catalog product
- Military QML certified for Military and Defense Applications

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