ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A HIGH-VOLTAGE HIGH-CURRENT DARLINGTON TRANSISTOR ARRAY

The ULN2001A is obsolete and is no longer supplied.

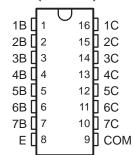
SLRS027G - DECEMBER 1976 - REVISED JUNE 2004

- 500-mA-Rated Collector Current (Single Output)
- High-Voltage Outputs . . . 50 V
- Output Clamp Diodes
- Inputs Compatible With Various Types of Logic
- Relay-Driver Applications

description/ordering information

The ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, and ULQ2004A are high-voltage, high-current Darlington transistor arrays. Each consists of seven npn Darlington pairs that feature high-voltage outputs

ULN2001A . . . D OR N PACKAGE
ULN2002A . . . N PACKAGE
ULN2003A . . . D, N, NS, OR PW PACKAGE
ULN2004A . . . D, N, OR NS PACKAGE
ULQ2003A, ULQ2004A . . . D OR N PACKAGE
(TOP VIEW)



with common-cathode clamp diodes for switching inductive loads. The collector-current rating of a single Darlington pair is 500 mA. The Darlington pairs can be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. For 100-V (otherwise interchangeable) versions of the ULN2003A and ULN2004A, see the SN75468 and SN75469, respectively.

ORDERING INFORMATION

TA	PACKA	GE†	ORDERABLE PART NUMBER	TOP-SIDE MARKING
			ULN2002AN	ULN2002AN
	PDIP (N)	Tube of 25	ULN2003AN	ULN2003AN
			ULN2004AN	ULN2004AN
		Tube of 40	ULN2003AD	LUAIGOGGA
	0010 (D)	Reel of 2500	ULN2003ADR	ULN2003A
–20°C to 70°C	SOIC (D)	Tube of 40	ULN2004AD	111 11000 44
		Reel of 2500	ULN2004ADR	ULN2004A
	000 (N0)	D1 - (0000	ULN2003ANSR	ULN2003A
	SOP (NS)	Reel of 2000	ULN2004ANSR	ULN2004A
	T000D (DW)	Tube of 90	ULN2003APW	LINIOGOA
	TSSOP (PW)	Reel of 2000	ULN2003APWR	UN2003A
	5515 (A.)	T	ULQ2003AN	ULQ2003A
	PDIP (N)	Tube of 25	ULQ2004AN	ULQ2004AN
4000 / 0500		Tube of 40	ULQ2003AD	ULQ2003A
–40°C to 85°C	0010 (D)	Reel of 2500	ULQ2003ADR	ULQ2003A
	SOIC (D)	Tube of 40	ULQ2004AD	ULQ2004A
		Reel of 2500	ULQ2004ADR	ULQ2004A

[†] Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.



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.



ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A

HIGH-VOLTAGE HIGH-CURRENT OF ARRAY

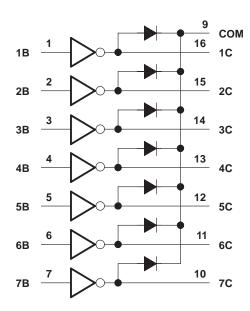
SLRS027G - DECEMBER 1976 - REVISED JUNE 2004

The ULN2001A is obsolete and is no longer supplied.

description/ordering information (continued)

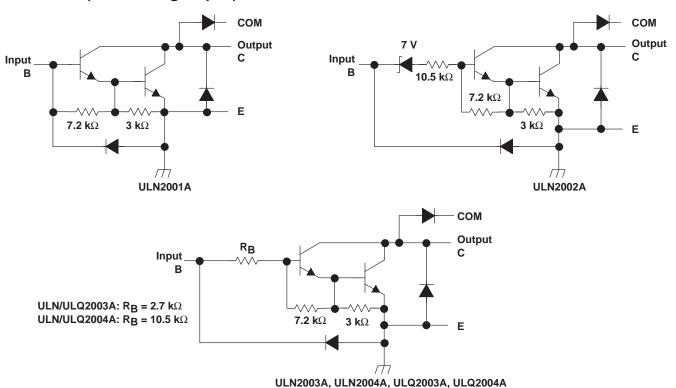
The ULN2001A is a general-purpose array and can be used with TTL and CMOS technologies. The ULN2002A is designed specifically for use with 14-V to 25-V PMOS devices. Each input of this device has a Zener diode and resistor in series to control the input current to a safe limit. The ULN2003A and ULQ2003A have a 2.7-k Ω series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices. The ULN2004A and ULQ2004A have a 10.5-k Ω series base resistor to allow operation directly from CMOS devices that use supply voltages of 6 V to 15 V. The required input current of the ULN/ULQ2004A is below that of the ULN/ULQ2003A, and the required voltage is less than that required by the ULN2002A.

logic diagram





schematics (each Darlington pair)



All resistor values shown are nominal.

ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A HIGH-VOLTAGE HIGH-CURRENT

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DARLINGTON TRANSISTOR ARRAY

The ULN2001A is obsolete and is no longer supplied.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)†

Collector-emitter voltage		50 V
Clamp diode reverse voltage (see Note 1)		
Input voltage, V _I (see Note 1)		30 V
Peak collector current (see Figures 14 and 15)		500 mA
Output clamp current, I _{OK}		500 mA
Total emitter-terminal current		–2.5 A
Operating free-air temperature range, T _A , ULN200xA .		. −20°C to 70°C
ULQ200xA		40°C to 85°C
ULQ200xAT		-40°C to 105°C
Package thermal impedance, θ_{JA} (see Notes 2 and 3):	D package	73°C/W
	N package	67°C/W
	NS package	64°C/W
	PW package	108°C/W
Package thermal impedance, θ_{JC} (see Notes 4 and 5):	D package	36°C/W
	N package	54°C/W
Operating virtual junction temperature, T _J		150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 s	seconds	260°C
Storage temperature range, T _{stq}		-65°C to 150°C

[†] 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.

NOTES: 1. All voltage values are with respect to the emitter/substrate terminal E, unless otherwise noted.

- 2. Maximum power dissipation is a function of $T_J(max)$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
- 3. The package thermal impedance is calculated in accordance with JESD 51-7.
- 4. Maximum power dissipation is a function of $T_J(max)$, θ_{JC} , and T_C . The maximum allowable power dissipation at any allowable case temperature is $P_D = (T_J(max) T_C)/\theta_{JC}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
- 5. The package thermal impedance is calculated in accordance with MIL-STD-883.

electrical characteristics, $T_A = 25^{\circ}C$ (unless otherwise noted)

24244555		TEST	TEST CONDITIONS		ULN2001A		A	UL			
	PARAMETER FIG		IESI CO	NDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
V _{I(on)}	On-state input voltage	6	V _{CE} = 2 V,	IC = 300 mA						13	V
	0.11		$I_{\parallel} = 250 \mu A$,	$I_C = 100 \text{ mA}$		0.9	1.1		0.9	1.1	
V _{CE(sat)}	Collector-emitter saturation voltage	5	$I_{I} = 350 \mu A$	$I_C = 200 \text{ mA}$		1	1.3		1	1.3	V
, ,	Saturation voltage		Ιι = 500 μΑ,	I _C = 350 mA		1.2	1.6		1.2	1.6	
٧F	Clamp forward voltage	8	$I_F = 350 \text{ mA}$			1.7	2		1.7	2	V
		1	V _{CE} = 50 V,	I _I = 0			50			50	
ICEX	Collector cutoff current		V _{CE} = 50 V, T _A = 70°C	I _I = 0			100			100	μΑ
		2		V _I = 6 V						500	
I _{I(off)}	Off-state input current	3	V _{CE} = 50 V, T _A = 70°C	I _C = 500 μA,	50	65		50	65		μΑ
lį	Input current	4	V _I = 17 V						0.82	1.25	mA
		_	$V_R = 50 V$,	T _A = 70°C			100			100	
IR	Clamp reverse current	7	V _R = 50 V				50			50	μΑ
h _{FE}	Static forward-current transfer ratio	5	V _{CE} = 2 V,	I _C = 350 mA	1000						
Ci	Input capacitance		$V_{I} = 0$,	f = 1 MHz		15	25		15	25	pF



ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A **HIGH-VOLTAGE HIGH-CURRENT** DARLINGTON TRANSISTOR ARRAY SLRS027G - DECEMBER 1976 - REVISED JUNE 2004

The ULN2001A is obsolete and is no longer supplied.

electrical characteristics, $T_A = 25^{\circ}C$ (unless otherwise noted) (continued)

PARAMETER		TEST	TEST CONDITIONS		UL	ULN2003A		UL	LINUT		
		FIGURE	IESI CO	TEST CONDITIONS		TYP	MAX	MIN	TYP	MAX	UNIT
				I _C = 125 mA						5	
				I _C = 200 mA			2.4			6	
.,	0		.,	$I_C = 250 \text{ mA}$			2.7				.,
V _{I(on)}	On-state input voltage	6	V _{CE} = 2 V	$I_C = 275 \text{ mA}$						7	V
				IC = 300 mA			3				
				I _C = 350 mA						8	
			I _I = 250 μA,	I _C = 100 mA		0.9	1.1		0.9	1.1	
VCE(sat)	Collector-emitter saturation voltage	5	I _I = 350 μA,	I _C = 200 mA		1	1.3		1	1.3	V
0=(00.0)	Saturation voltage		I _I = 500 μA,	$I_C = 350 \text{ mA}$		1.2	1.6		1.2	1.6	
		1	$V_{CE} = 50 \text{ V},$	I _I = 0			50			50	
ICEX	Collector cutoff current	_	V _{CE} = 50 V,	I _I = 0			100			100	μΑ
		2	T _A = 70°C	V _I = 1 V						500	
٧F	Clamp forward voltage	8	I _F = 350 mA			1.7	2		1.7	2	V
I _{I(off)}	Off-state input current	3	V _{CE} = 50 V, T _A = 70°C	$I_C = 500 \mu A,$	50	65		50	65		μΑ
			V _I = 3.85 V			0.93	1.35				
l _i	Input current	4	V _I = 5 V						0.35	0.5	mA
			V _I = 12 V						1	1.45	
		_	V _R = 50 V				50			50	
IR	Clamp reverse current	7	$V_R = 50 V$,	T _A = 70°C			100			100	μΑ
Ci	Input capacitance		$V_{I} = 0$,	f = 1 MHz		15	25		15	25	pF

ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A HIGH-VOLTAGE HIGH-CURRENT

HIGH-VOLTAGE HIGH-CURRENT DARLINGTON TRANSISTOR ARRAY SLRS027G - DECEMBER 1976 - REVISED JUNE 2004

The ULN2001A is obsolete and is no longer supplied.

electrical characteristics over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST		NEITIONS	UL	Q2003/	4	UL	Q2004	4								
		FIGURE	NDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNIT								
				I _C = 125 mA						5								
				$I_C = 200 \text{ mA}$			2.7			6								
.,			., .,	$I_C = 250 \text{ mA}$			2.9				.,							
V _{I(on)}	On-state input voltage	6	V _{CE} = 2 V	I _C = 275 mA						7	V							
				I _C = 300 mA			3											
				I _C = 350 mA						8								
			Ι _Ι = 250 μΑ,	I _C = 100 mA		0.9	1.2		0.9	1.1								
VCE(sat)	Collector-emitter saturation voltage	5	Ι _Ι = 350 μΑ,	I _C = 200 mA		1	1.4		1	1.3	V							
(13.7)	Saturation voltage		I _I = 500 μA,	$I_C = 350 \text{ mA}$		1.2	1.7		1.2	1.6								
		1	$V_{CE} = 50 \text{ V},$	$I_I = 0$			100			50								
ICEX	Collector cutoff current	_	V _{CE} = 50 V	I _I = 0						100	μΑ							
		2		vCE = 20 A	VCE = 20 V	VCE = 50 V	vCE = 20 v	ΛCE = 20 Λ	ACE = 20 A	vCE = 20 v	vCE = 20 v	V _I = 1 V						500
٧F	Clamp forward voltage	8	$I_F = 350 \text{ mA}$			1.7	2.3		1.7	2	V							
I _{I(off)}	Off-state input current	3	V _{CE} = 50 V,	I _C = 500 μA		65		50	65		μΑ							
			V _I = 3.85 V			0.93	1.35											
Ц	Input current	4	V _I = 5 V						0.35	0.5	mA							
			V _I = 12 V						1	1.45								
	Claren navana augus si	7	$V_R = 50 V$,	T _A = 25°C			100			50								
I _R	Clamp reverse current	7	V _R = 50 V				100			100	μΑ							
C _i	Input capacitance		$V_{I} = 0$,	f = 1 MHz		15	25	_	15	25	pF							

switching characteristics, $T_A = 25^{\circ}C$

	PARAMETER	TEST CONDITIONS	ULN2001/ ULN2003/	UNIT		
			MIN	TYP	MAX	
tPLH	Propagation delay time, low- to high-level output	See Figure 9		0.25	1	μs
tPHL	Propagation delay time, high- to low-level output	See Figure 9		0.25	1	μs
Vон	High-level output voltage after switching	$V_S = 50 \text{ V}, \qquad I_O \approx 300 \text{ mA},$ See Figure 10	V _S -20		·	mV

switching characteristics over recommended operating conditions (unless otherwise noted)

	DADAMETER		ULQ2003			
	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
^t PLH	Propagation delay time, low- to high-level output	See Figure 9		1	10	μs
tPHL	Propagation delay time, high- to low-level output	See Figure 9		1	10	μs
Vон	High-level output voltage after switching	$V_S = 50 \text{ V}, \qquad I_O \approx 300 \text{ mA},$ See Figure 10	V _S -500			mV



PARAMETER MEASUREMENT INFORMATION

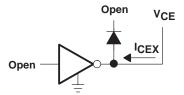


Figure 1. I_{CEX} Test Circuit

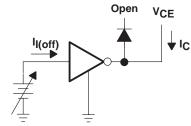
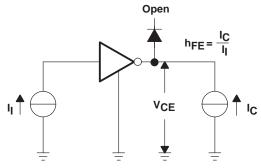


Figure 3. I_{I(off)} Test Circuit



NOTE: I_I is fixed for measuring $V_{\text{CE(sat)}}$, variable for measuring h_{FE}.

Figure 5. hFE, VCE(sat) Test Circuit

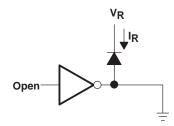


Figure 7. IR Test Circuit

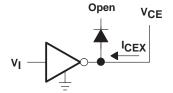


Figure 2. I_{CEX} Test Circuit

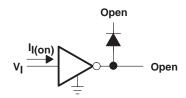


Figure 4. I_I Test Circuit

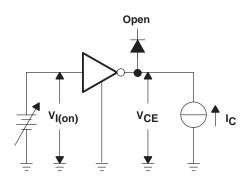


Figure 6. V_{I(on)} Test Circuit

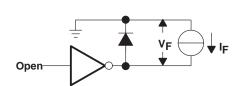


Figure 8. V_F Test Circuit

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PARAMETER MEASUREMENT INFORMATION

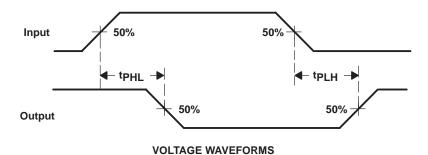
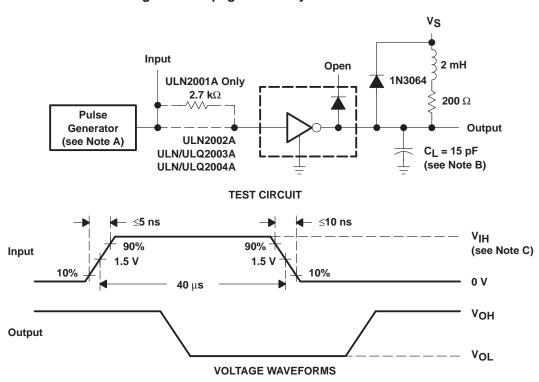


Figure 9. Propagation Delay-Time Waveforms



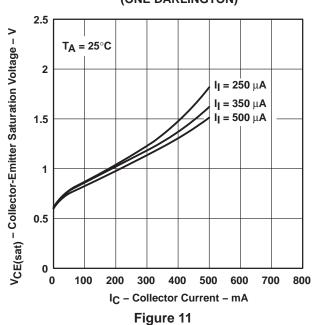
- NOTES: A. The pulse generator has the following characteristics: PRR = 12.5 kHz, $Z_O = 50 \Omega$.
 - B. C_L includes probe and jig capacitance.
 - C. For testing the ULN2001A, the ULN2003A, and the ULQ2003A, V_{IH} = 3 V; for the ULN2002A, V_{IH} = 13 V; for the ULN2004A and the ULQ2004A, V_{IH} = 8 V.

Figure 10. Latch-Up Test Circuit and Voltage Waveforms



TYPICAL CHARACTERISTICS

COLLECTOR-EMITTER
SATURATION VOLTAGE
vs
COLLECTOR CURRENT
(ONE DARLINGTON)



COLLECTOR-EMITTER
SATURATION VOLTAGE
vs
TOTAL COLLECTOR CURRENT
(TWO DARLINGTONS IN PARALLEL)

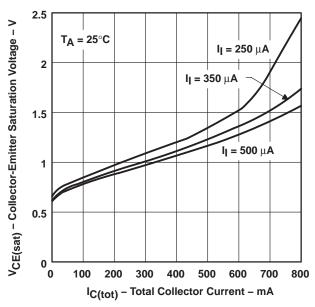


Figure 12

COLLECTOR CURRENT

INPUT CURRENT 500 $R_L = 10 \Omega$ 450 T_A = 25°C 400 Ic - Collector Current - mA Vs = 10 V 350 V_S = 8 V 300 250 200 150 100 50 0 0 25 50 75 100 125 150 175 200 I_I - Input Current - μA

Figure 13



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THERMAL INFORMATION

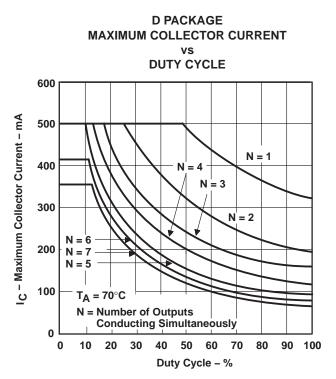


Figure 14

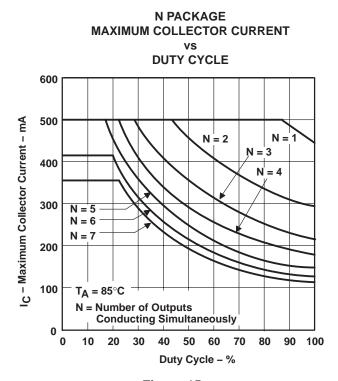


Figure 15

APPLICATION INFORMATION

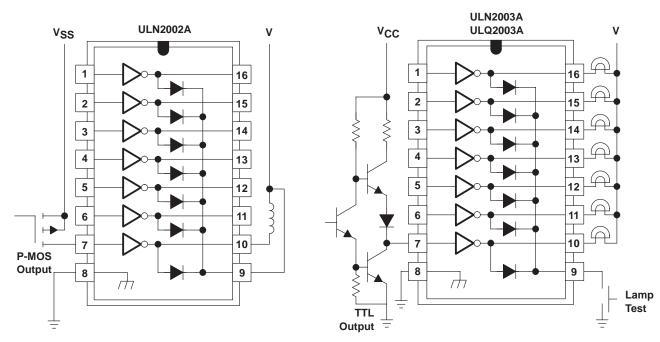


Figure 16. P-MOS to Load

Figure 17. TTL to Load

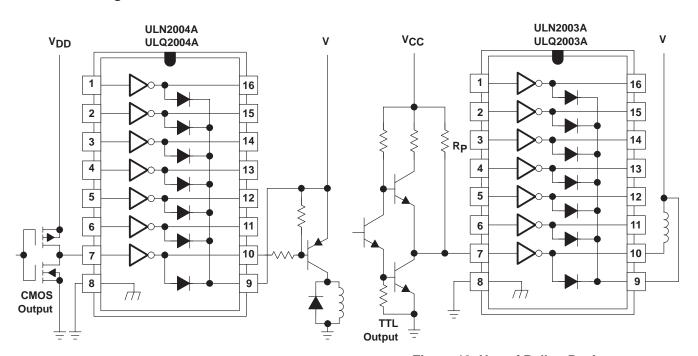


Figure 18. Buffer for Higher Current Loads

Figure 19. Use of Pullup Resistors to Increase Drive Current









PACKAGING INFORMATION

CROHS Level-1-235C-UNLIM	Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
ULN2001AN	ULN2001AD	OBSOLETE	SOIC	D	16		None	Call TI	Call TI
ULN2002AD OBSOLETE SOIC D 16	ULN2001ADR	OBSOLETE	SOIC	D	16		None	Call TI	Call TI
ULN2003AN	ULN2001AN	OBSOLETE	PDIP	N	16		None	Call TI	Call TI
CROHS ULN2003AD	ULN2002AD	OBSOLETE	SOIC	D	16		None	Call TI	Call TI
CROHS Level-1-235C-UNLIM	ULN2002AN	ACTIVE	PDIP	N	16	25		CU NIPDAU	Level-NC-NC-NC
No Sb/Br	ULN2003AD	ACTIVE	SOIC	D	16	40		CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
ULN2003AN	ULN2003ADR	ACTIVE	SOIC	D	16	2500	`	Call TI	Level-1-260C-UNLIM
ULN2003ANSR	ULN2003AJ	OBSOLETE	CDIP	J	16		None	Call TI	Call TI
CROHS Level-1-235C-UNLIM	ULN2003AN	ACTIVE	PDIP	N	16	25		CU NIPDAU	Level-NC-NC-NC
CROHS ULN2003APWR	ULN2003ANSR	ACTIVE	SO	NS	16	2000		CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
CROHS	ULN2003APW	ACTIVE	TSSOP	PW	16	90		CU NIPDAU	Level-1-250C-UNLIM
CROHS Level-1-235C-UNLIM	ULN2003APWR	ACTIVE	TSSOP	PW	16	2000		CU NIPDAU	Level-1-250C-UNLIM
No Sb/Br No Sb/Br	ULN2004AD	ACTIVE	SOIC	D	16	40		CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
ULN2004ANSR	ULN2004ADR	ACTIVE	SOIC	D	16	2500	,	Call TI	Level-1-260C-UNLIM
ULQ2003AD	ULN2004AN	ACTIVE	PDIP	N	16	25		CU NIPDAU	Level-NC-NC-NC
CROHS Level-1-235C-UNLIM	ULN2004ANSR	ACTIVE	SO	NS	16	2000		CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
CROHS Level-1-235C-UNLIM	ULQ2003AD	ACTIVE	SOIC	D	16	40		CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
ULQ2004AD ACTIVE SOIC D 16 40 Pb-Free CU NIPDAU Level-2-250C-1 YEAF (RoHS) ULQ2004ADR ACTIVE SOIC D 16 2500 Pb-Free CU NIPDAU Level-2-250C-1 YEAF (RoHS) Level-1-235C-UNLIM	ULQ2003ADR	ACTIVE	SOIC	D	16	2500		CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
(RoHS) Level-1-235C-UNLIM	ULQ2003AN	ACTIVE	PDIP	N	16	25	None	Call TI	Level-NC-NC-NC
(RoHS) Level-1-235C-UNLIM	ULQ2004AD	ACTIVE	SOIC	D	16	40		CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
LILOGODAAN ACTIVE DDID N. 46 05 None Collist Level NO NO NO	ULQ2004ADR	ACTIVE	SOIC	D	16	2500		CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
OLGZOU4AN ACTIVE PDIP IN 16 25 NONE CALL II LEVEL-NC-NC	ULQ2004AN	ACTIVE	PDIP	N	16	25	None	Call TI	Level-NC-NC-NC

(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.

None: Not yet available Lead (Pb-Free).

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements

⁽²⁾ Eco Plan - May not be currently available - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.



PACKAGE OPTION ADDENDUM

8-Mar-2005

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.

Green (RoHS & no Sb/Br): TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

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

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14 LEADS SHOWN



- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. This package is hermetically sealed with a ceramic lid using glass frit.
- D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
- E. Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

N (R-PDIP-T**)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN

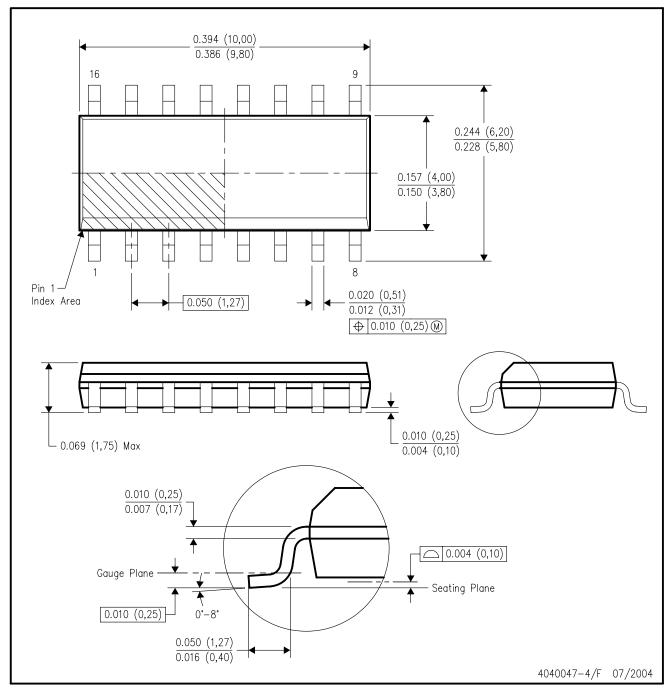


- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
- The 20 pin end lead shoulder width is a vendor option, either half or full width.



D (R-PDSO-G16)

PLASTIC SMALL-OUTLINE PACKAGE



- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
- D. Falls within JEDEC MS-012 variation AC.



MECHANICAL DATA

NS (R-PDSO-G**)

14-PINS SHOWN

PLASTIC SMALL-OUTLINE PACKAGE



- 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, not to exceed 0,15.



PW (R-PDSO-G**)

14 PINS SHOWN

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 not to exceed 0,15.

D. Falls within JEDEC MO-153

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