High Darlington Transistor Arrays IC

Description

The ULN2003A and ULN2004A are high voltage, high current Darlington arrays each containing seven open collector common emitter pairs. Each pair is rated at 500mA. Suppression diodes are included for inductive load driving, the inputs and outputs are pinned in opposition to simplify board layout.

Device options are designed to be compatible with common logic families:

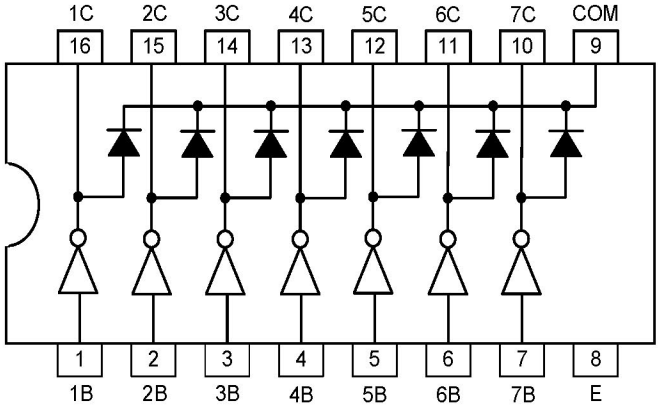
ULN2003A (5V TTL, CMOS) ULN2004A (6-15V CMOS, PMOS)

These devices are capable of driving a wide range of loads including solenoids, relays, DC motors, LED displays, filament lamps, thermal print-heads and high-power buffers.

Features

- 500mA Rated Collector Current (Single Output)
- High Voltage Outputs: 50V
- High output current : 500mA
- Output Clamp Diodes
- Inputs Compatible with Popular Logic Types
- Relay Driver Applications

PIN Diagram



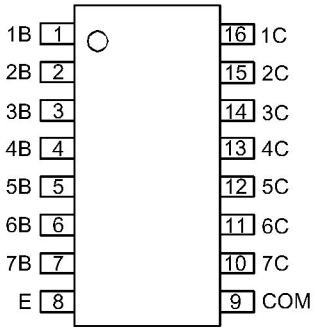
Applications

- Relay driver
- DC Brushed Motor
- Drivers Display Drivers
- Magnet valve
- Logic Buffers

Ordering Information

Part Number	Package	Packing	Temperature（T_A）	Package Qty	Note
ULN2003ADR	SOIC-16	Reel	-40°C ~ 70°C	2500	
ULN2003AIDR	SOIC-16	Reel	-40°C ~ 105°C	2500	
ULN2003APWR	TSSOP-16	Reel	-40°C ~ 70°C	2500	
ULN2003AIPWR	TSSOP-16	Reel	-40°C ~ 105°C	2500	
ULN2004ADR	SOIC-16	Reel	-40°C ~ 70°C	2500	
ULN2004AIDR	SOIC-16	Reel	-40°C ~ 105°C	2500	

(Top View)

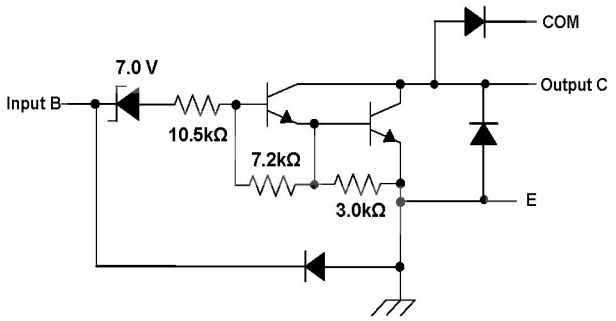


SOIC-16

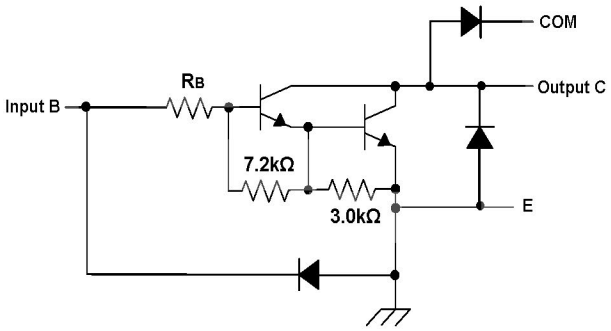
Pin Descriptions

Pin Number SOIC-16/TSSOP-16	Pin Name	Function
1	1B	Input Pair 1
2	2B	Input Pair 2
3	3B	Input Pair 3
4	4B	Input Pair 4
5	5B	Input Pair 5
6	6B	Input Pair 6
7	7B	Input Pair 7
8	E	Common Emitter (Ground)
9	COM	Common Clamp Diodes
10	7C	Output Pair 7
11	6C	Output Pair 6
12	5C	Output Pair 5
13	4C	Output Pair 4
14	3C	Output Pair 3
15	2C	Output Pair 2
16	1C	Output Pair 1

Functional Block Diagram



ULN2002A



ULN2003A: R_B = 2.7k
ULN2004A: R_B = 10.5k

ULN2003A, ULN2004A

Absolute Maximum Ratings (Note 4) (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter		Rating	Unit
V_{CC}	Collector to Emitter Voltage		50	V
V_R	Clamp Diode Reverse Voltage (Note 5)		50	V
V_I	Input Voltage (Note 5)		30	V
I_{CP}	Peak Collector Current		500	mA
I_{OK}	Output Clamp Current		500	mA
I_{TE}	Total Emitter Current		-2.5	A
θ_{JA}	Thermal Resistance Junction-to-Ambient (Note 6)	SO-16	63.0	°C/W
		PDIP-16	50.0	
θ_{JC}	Thermal Resistance Junction-to-Case (Note 7)	SO-16	12.0	°C/W
		PDIP-16	15.0	
T_J	Junction Temperature		+150	°C
T_{STG}	Storage Temperature		-65 to +150	°C

Notes:
4. Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only. 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.
5. All voltage values are with respect to the emitter/substrate terminal E, unless otherwise noted.
6. 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.
7. Maximum power dissipation is a function of $T_J(max)$, θ_{JC} and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_C)/\theta_{JC}$. Operating at the absolute maximum T_J of +150°C can affect reliability.

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V_{CC}	Collector to Emitter Voltage	—	50	V
T_A	Operating Ambient Temperature Normal level	-40	+70	°C
T_A	Operating Ambient Temperature Level "I"	-40	+105	°C

Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

ULN2002A							
Symbol	**Parameter**	**Test Figure**	**Test Conditions**	**Min**	**Typ**	**Max**	**Unit**
$V_{I(ON)}$	On State Input Voltage	6	V_{CE} = 2V, I_C = 300mA	—	—	13	V
$V_{CE(SAT)}$	Collector Emitter Saturation Voltage	5	I_I = 250μA, I_C = 100mA	—	0.9	1.1	V
			I_I = 350μA, I_C = 200mA	—	1	1.3	
			I_I = 500μA, I_C = 350mA	—	1.2	1.6	
V_F	Clamp Forward Voltage	8	I_F = 350mA	—	1.7	2	V
I_{CEX}	Collector Cut-off Current	1	V_{CE} = 50V, I_I = 0	—	—	50	μA
		2	V_{CE} = 50V, T_A = +105°C; I_I = 0	—	—	100	
			V_I = 6V	—	—	500	
$I_{I(OFF)}$	Off State Input Current	3	V_{CE} = 50V, I_C = 500μA	50	65	—	μA
I_I	Input Current	4	V_I = 17V	—	0.82	1.25	mA
I_R	Clamp Reverse Current	7	V_R = 50V; T_A = +105°C	—	—	100	μA
			—	—	—	50	
C_I	Input Capacitance	—	V_I = 0, f = 1MHz	—	—	25	pF

Electrical Characteristics (Cont.) (@T_A = +25°C, unless otherwise specified.)

ULN2003A

Parameter		Test Figure	Test Conditions		Min	Typ	Max	Unit
$V_{I(ON)}$	On State Input Voltage	6	V_{CE} = 2V	I_C = 200mA	—	—	2.4	V
				I_C = 250mA	—	—	2.7	
				I_C = 300mA	—	—	3	
$V_{CE(SAT)}$	Collector Emitter Saturation Voltage	5	I_I = 250μA, I_C = 100mA		—	0.9	1.1	V
			I_I = 350μA, I_C = 200mA		—	1	1.3	
			I_I = 500μA, I_C = 350mA		—	1.2	1.6	
V_F	Clamp Forward Voltage	8	I_F = 350mA		—	1.7	2	V
I_{CEX}	Collector Cut-off Current	1	V_{CE} = 50V, I_I = 0		—	—	50	μA
		2	V_{CE} = 50V, T_A = +105°C	I_I = 0	—	—	100	
$I_{I(OFF)}$	Off State Input Current	3	V_{CE} = 50V, I_C = 500μA		50	65	—	μA
I_I	Input Current	4	V_I = 3.85V		—	0.93	1.35	mA
I_R	Clamp Reverse Current	7	V_R = 50V	T_A = +105°C	—	—	100	μA
				—	—	—	50	
C_I	Input Capacitance	—	V_I = 0, f = 1MHz		—	15	25	pF

ULN2004A

Parameter		Test Figure	Test Conditions		Min	Typ	Max	Unit
$V_{I(ON)}$	On State Input Voltage	6	V_{CE} = 2V	I_C = 125mA	—	—	5	V
				I_C = 200mA	—	—	6	
				I_C = 275mA	—	—	7	
				I_C = 350mA	—	—	8	
$V_{CE(SAT)}$	Collector Emitter Saturation Voltage	5	I_I = 250μA, I_C = 100mA		—	0.9	1.1	V
			I_I = 350μA, I_C = 200mA		—	1	1.3	
			I_I = 500μA, I_C = 350mA		—	1.2	1.6	
V_F	Clamp Forward Voltage	8	I_F = 350mA		—	1.7	2	V
I_{CEX}	Collector Cut-off Current	1	V_{CE} = 50V, I_I = 0		—	—	50	μA
		2	V_{CE} = 50V, T_A = +105°C	I_I = 0	—	—	100	
				V_I = 6V	—	—	500	
$I_{I(OFF)}$	Off State Input Current	3	V_{CE} = 50V, I_C = 500μA		50	65	—	μA
I_I	Input Current	4	V_I = 5V		—	0.35	0.5	mA
I_R	Clamp Reverse Current	7	V_R = 50V	T_A = +105°C	—	—	100	μA
				—	—	—	50	
C_I	Input Capacitance	—	V_I = 0, f = 1MHz		—	15	25	pF

Electrical Characteristics (Cont.) (@T_A = -40°C to +105°C, unless otherwise specified.)

ULN2003A								
Parameter		Test Figure	Test Conditions		Min	Typ	Max	Unit
$V_{I(ON)}$	On State Input Voltage	6	V_{CE} = 2V	I_C = 200mA	—	—	2.7	V
				I_C = 250mA	—	—	2.9	
				I_C = 300mA	—	—	3	
$V_{CE(SAT)}$	Collector Emitter Saturation Voltage	5	I_I = 250μA, I_C = 100mA		—	0.9	1.2	V
			I_I = 350μA, I_C = 200mA		—	1	1.4	
			I_I = 500μA, I_C = 350mA		—	1.2	1.7	
V_F	Clamp Forward Voltage	8	I_F = 350mA		—	1.7	2.2	V
I_{CEX}	Collector Cut-off Current	1	V_{CE} = 50V, I_I = 0		—	—	100	μA
$I_{I(OFF)}$	Off State Input Current	3	V_{CE} = 50V, I_C = 500μA		30	65	—	μA
I_I	Input Current	4	V_I = 3.85V		—	0.93	1.35	mA
I_R	Clamp Reverse Current	7	V_R = 50V		—	—	100	μA
C_I	Input Capacitance	—	V_I = 0, f = 1MHz		—	15	25	pF

Switching Characteristics (@T_A = +25°C, unless otherwise specified.)

ULN2002A, ULN2003A, ULN2004A						
Parameter		Test figure	Min	Typ	Max	Unit
t_{PLH}	Propagation Delay Time, Low to High Level Output	9	—	0.25	1	μs
t_{PHL}	Propagation Delay Time, High to Low Level Output	9	—	0.25	1	μs
V_{OH}	High Level Output Voltage after Switching	9 (V_S = 50V, I_O = 300mA)	V_S-20	—	—	mV

Switching Characteristics (@T_A = -40 to +105°C, unless otherwise specified.)

ULN2003A						
Parameter		Test figure	Min	Typ	Max	Unit
t_{PLH}	Propagation Delay Time, Low to High Level Output	9	—	1	10	μs
t_{PHL}	Propagation Delay Time, High to Low Level Output	9	—	1	10	μs
V_{OH}	High Level Output Voltage after Switching	9 (V_S = 50V, I_O = 300mA)	V_S-50	—	—	mV

Parameter Measurement Circuits

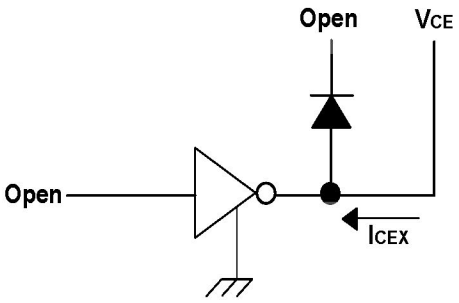


Fig.1 I_{CEX} Test Circuit

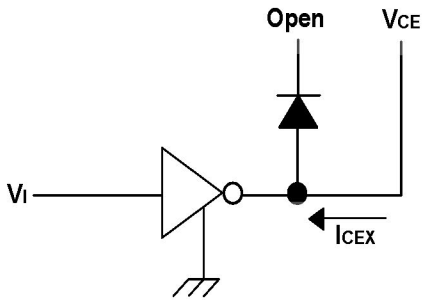


Fig.2 I_{CEX} Test Circuit

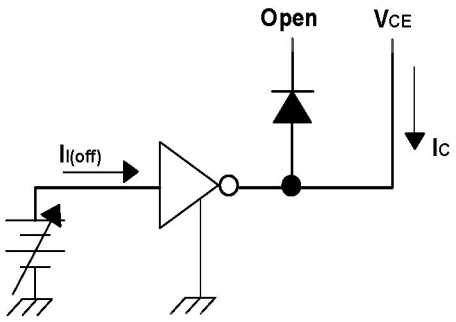


Fig.3 $I_{I(off)}$ Test Circuit

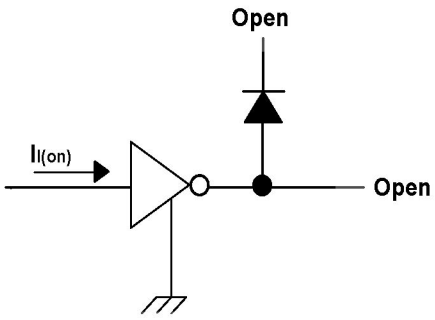


Fig.4 I_I Test Circuit

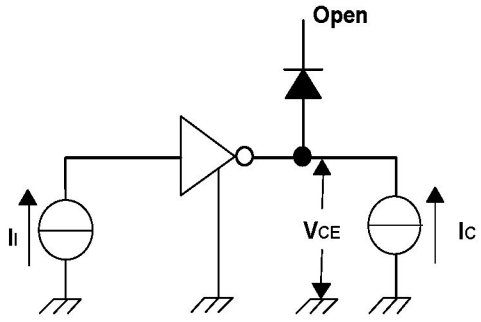


Fig. 5 h_{FE} , $V_{CE(sat)}$ Test Circuit

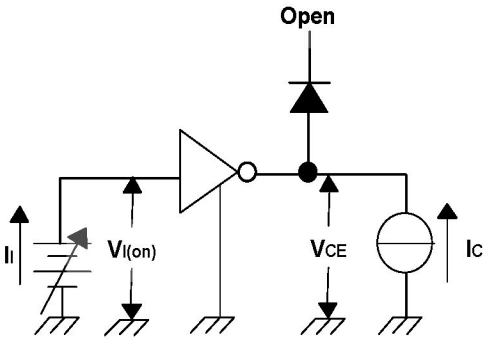


Fig. 6 $V_{I(on)}$ Test Circuit

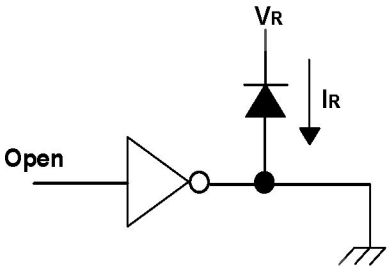


Fig. 7 I_R Test Circuit

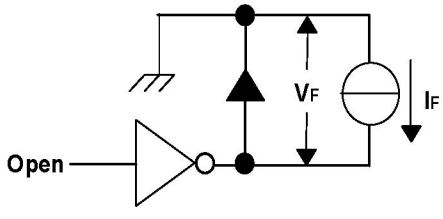


Fig. 8 V_F Test Circuit

Parameter Measurement Circuits (Cont.)

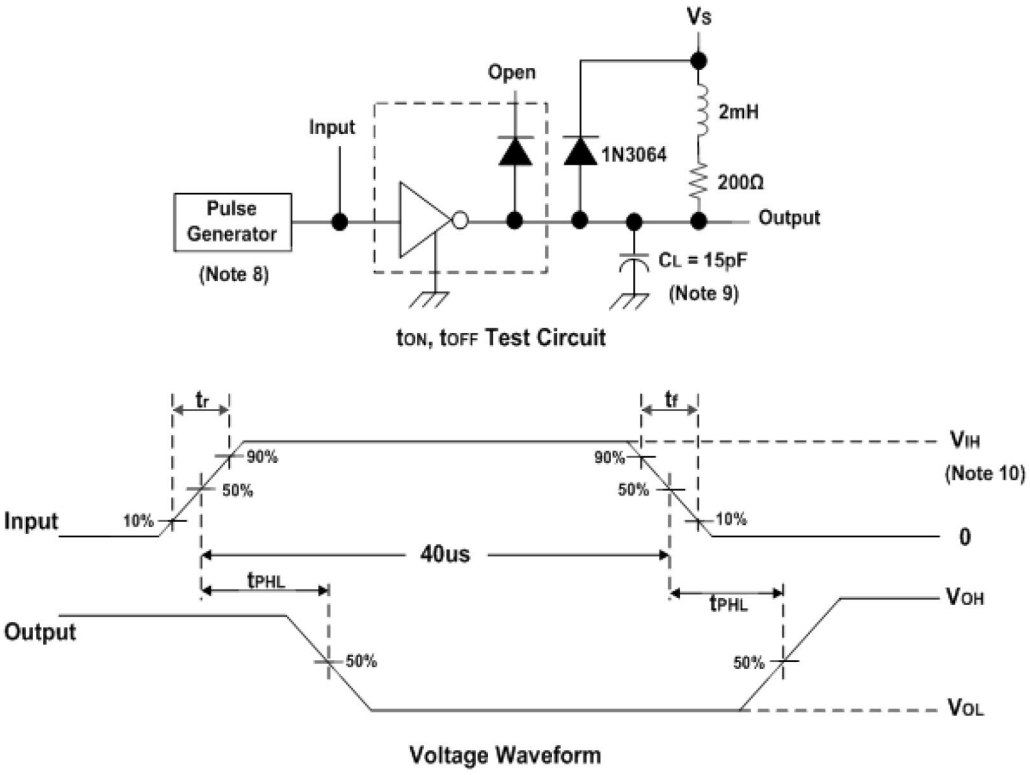
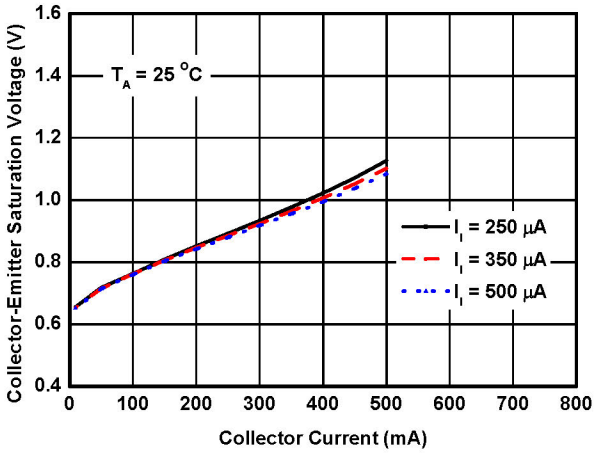


Fig. 9 Latch-Up Test Circuit and Voltage Waveform

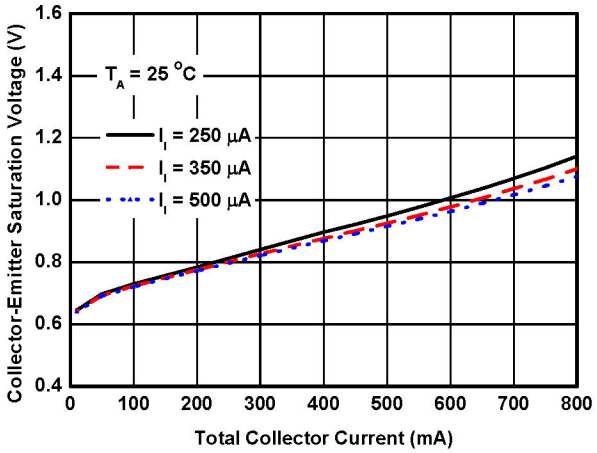
Notes: 8. The pulse generator has the following characteristics: Pulse Width = 12.5Hz, output impedance 50Ω, tr ≤ 5ns, tr ≤ 10ns.
9. C_L includes prove and jig capacitance.
10. For testing the ULN2002A, V_{IH} = 13V; for the ULN2003A, V_{IH} = 3V; for the ULN2004A, V_{IH} = 8V.

Typical Performance Characteristics

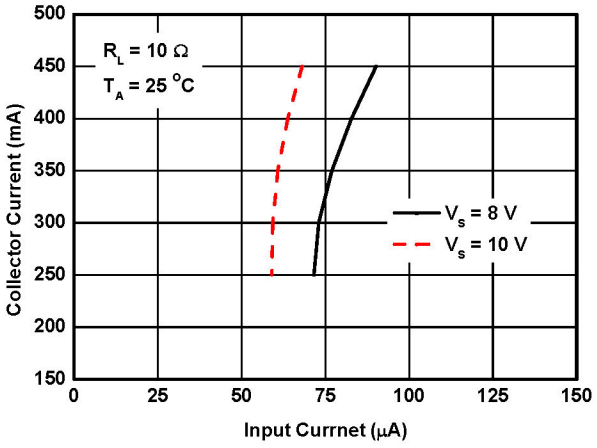
Collector-Emitter Saturation Voltage vs. Collector Current (One Darlington)



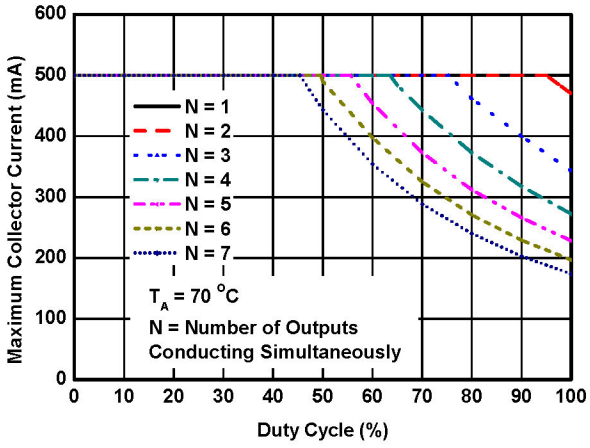
Collector-Emitter Saturation Voltage vs. Collector Current (Two Darlington in Parallel)



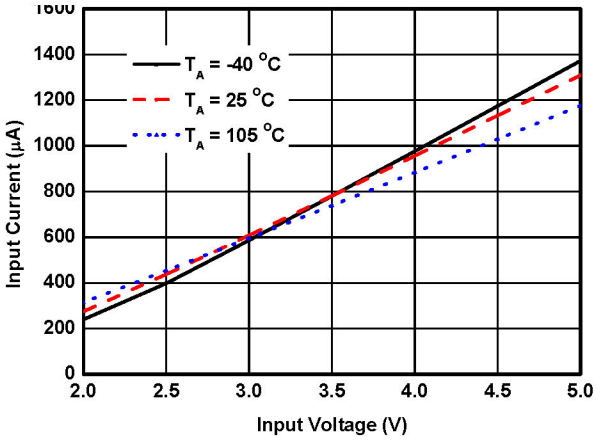
Collector Current vs. Input Current



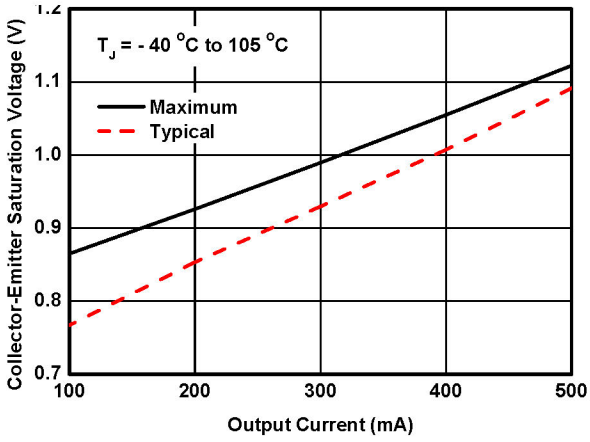
Maximum Collector Current vs. Duty Cycle



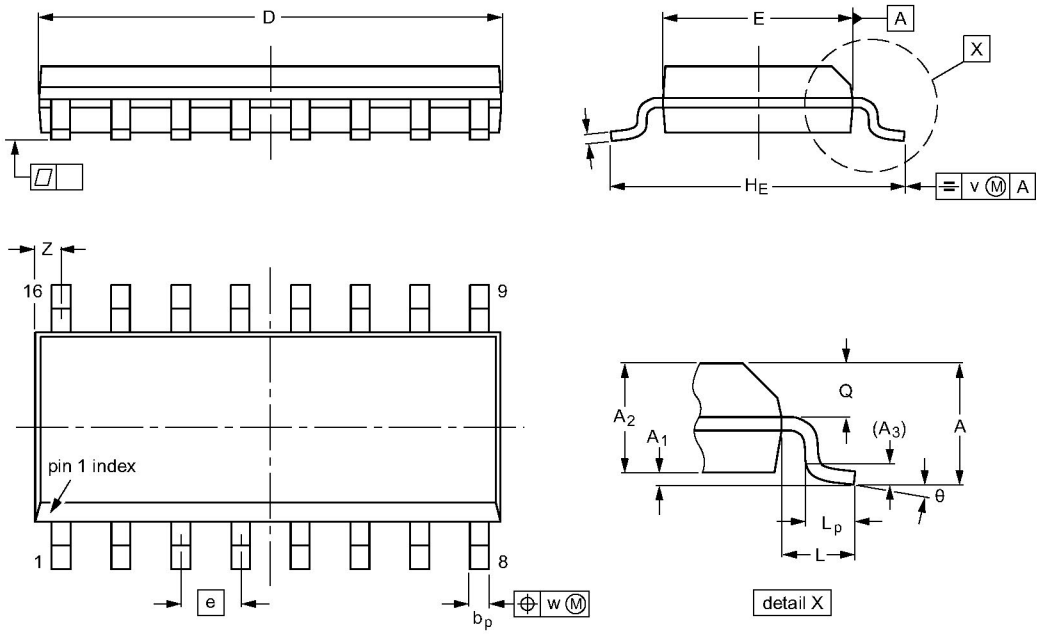
Input Current vs. Input Voltage



Collector-Emitter Saturation Voltage vs. Output Current



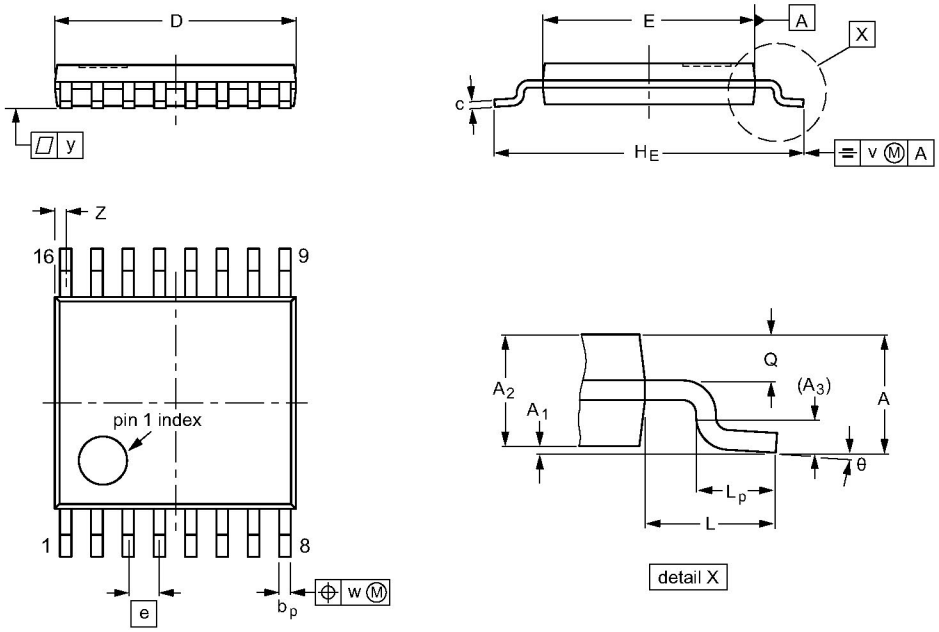
SOIC16: plastic small outline package; 16 leads; body width 3.9 mm



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(1)}$	e	H_E	L	L_p	Q	v	w	y	$Z^{(1)}$	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	10.0 9.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0

TSSOP16: plastic thin shrink small outline package; 16 leads; body width 4.4 mm



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(2)}$	e	H_E	L	L_p	Q	v	w	y	$Z^{(1)}$	θ
mm	1.1	0.15 0.05	0.95 0.80	0.25	0.30 0.19	0.2 0.1	5.1 4.9	4.5 4.3	0.65	6.6 6.2	1	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.40 0.06	8° 0°