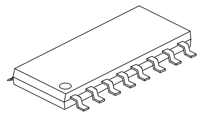
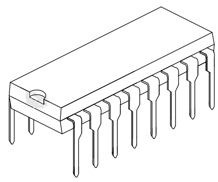
7CH DARLINGTON SINK DRIVER



SOP-16



DIP-16

■ DESCRIPTION

The UTC **ULN2003** are high-voltage, high-current darlington drivers comprised of seven NPN Darlington pairs.

All units feature integral clamp diodes for switching inductive loads.

Applications include relay, hammer, lamp and display (LED) drivers.

■ FEATURES

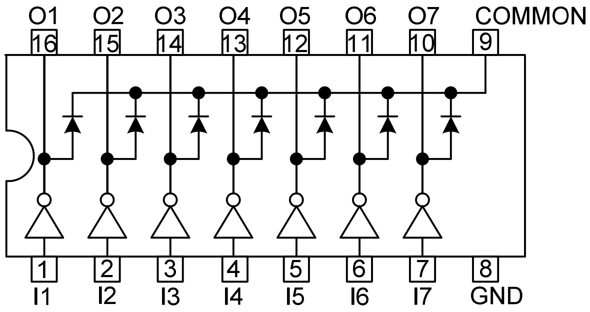
*Output Current (Single Output): 500mA (MAX.)
*High Sustaining Voltage Output: 50V (MIN.)
*Output Clamp Diodes
*Inputs Compatible With Various Types Of Logic

■ ORDERING INFORMATION

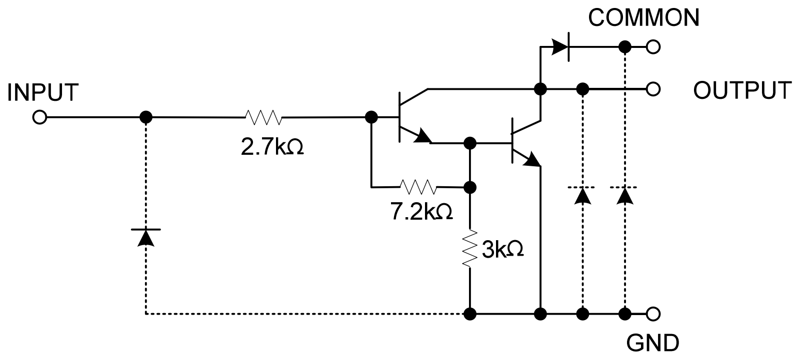
Ordering Number		Package	Packing
Lead Free	Halogen Free		
ULN2003L-D16-T	ULN2003G-D16-T	DIP-16	Tube
ULN2003L-S16-R	ULN2003G-S16-R	SOP-16	Tape Reel
ULN2003L-S16-T	ULN2003G-S16-T	SOP-16	Tube

ULN2003L-D16-T (1)Packing Type (2)Package Type (3)Lead Free	(1) R: Tape Reel, T: Tube (2) D16: DIP-16, S16: SOP-16 (3) G: Halogen Free, L: Lead Free

■ PIN CONNECTION



■ BLOCK DIAGRAM



Note: The input and output parasitic diodes cannot be used as clamp diodes.

■ ABSOLUTE MAXIMUM RATINGS (T_A=25°C)

PARAMETER		SYMBOL	RATING	UNIT
Output Sustaining Voltage		V_{OUT}	-0.5~50	V
Input Voltage		V_{IN}	-0.5~30	V
Clamp Diode Reverse Voltage		V_R	50	V
Output Current		I_{OUT}	500	mA / ch
Clamp Diode Forward Current		I_F	500	mA
Power Dissipation	DIP-16	P_D	1.47	W
	SOP-16		1.25 (Note2)	W
Junction Temperature		T_J	+125	°C
Operating Temperature		T_{OPR}	-40~+85	°C
Storage Temperature		T_{STG}	-55~+150	°C

Note: 1. Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.
2. On PCB (Test Board: JEDEC 2s2p)

■ RECOMMENDED OPERATING CONDITIONS (T_A=-40～+85°C)

CHARACTERISTIC		SYMBOL	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Output Sustaining Voltage		V_{OUT}			0		50	V
Output Current	DIP-16	I_{OUT}	T_{PW} = 25ms	Duty = 10%	0		350	mA/ch
			7 Circuits	Duty = 50%	0		100	
	SOP-16		T_A = 85°C	Duty = 10%	0		300	
			T_J = 120°C	Duty = 50%	0		90	
Input Voltage		V_{IN}			0		24	V
Input Voltage (Output On)		$V_{IN (ON)}$	I_{OUT} = 400mA		2.8		24	V
Input Voltage (Output Off)		$V_{IN (OFF)}$			0		0.7	V
Clamp Diode Reverse Voltage		V_R					50	V
Clamp Diode Forward Current		I_F					350	mA
Power Dissipation	DIP-16	P_D	T_A = 85°C				0.76	W
	SOP-16		T_A = 85°C (Note)				0.65	

Note: On PCB (Test Board: JEDEC 2s2p)

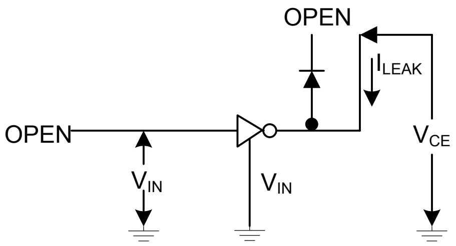
■ ELECTRICAL CHARACTERISTICS (T_A=25°C unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CIRCUIT	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Output Leakage Current	I_{LEAK}	1	V_{CE} = 50 V, T_A = 25°C				50	μA
			V_{CE} = 50 V, T_A = 85°C				100	
Collector-Emitter Saturation Voltage	$V_{CEO(SAT)}$	2	I_{OUT} = 350 mA, I_{IN} = 500 μA			1.3	1.6	V
			I_{OUT} = 200 mA, I_{IN} = 350 μA			1.1	1.3	
			I_{OUT} = 100 mA, I_{IN} = 250 μA			0.9	1.1	
DC Current Transfer Ratio	h_{FE}	2	V_{CE} = 2 V, I_{OUT} = 350 mA		1000			
Input Current (Output On)	$I_{IN (ON)}$	3	V_{IN} = 2.4 V, I_{OUT} = 350 mA			0.4	0.7	mA
Input Current (Output Off)	$I_{IN (OFF)}$	4	I_{OUT} = 500 μA, T_A = 85°C		50	65		μA
Input Voltage (Output On)	$V_{IN(ON)}$	5	V_{CE} = 2 V	I_{OUT} = 350 mA			2.6	V
				I_{OUT} = 200 mA			2.0	
Clamp Diode Reverse Current	I_R	6	V_R = 50 V, T_A = 25°C				50	μA
			V_R = 50 V, T_A = 85°C				100	
Clamp Diode Forward Voltage	V_F	7	I_F = 350 mA				2.0	V
Input Capacitance	C_{IN}					15		pF
Turn-On Delay	t_{ON}	8	V_{OUT} = 50 V, R_L = 125 Ω C_L = 15 pF			0.1		μs
Turn-Off Delay	t_{OFF}	8	V_{OUT} = 50 V, R_L = 125 Ω C_L = 15 pF			0.2		

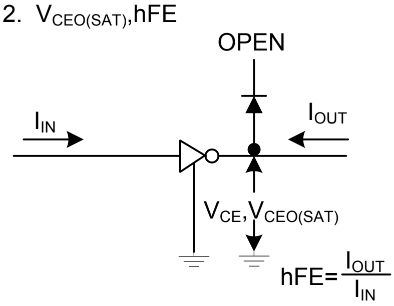
■ TEST CIRCUIT

Components in the test circuits are used only to obtain and confirm the device characteristics. These components and circuits are not guaranteed to prevent malfunction or failure from occurring in the application equipment.

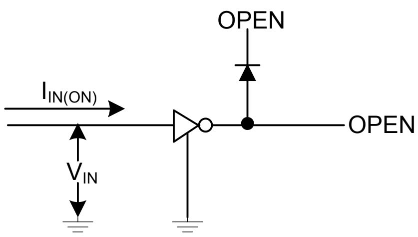
1. I_{LEAK}



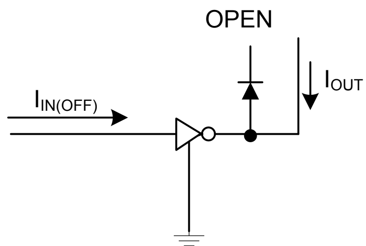
2. $V_{CEO(SAT)}$,hFE



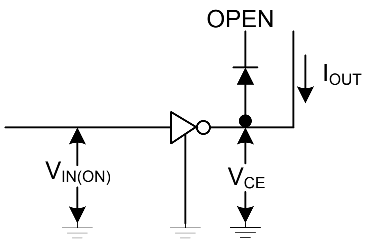
3. $I_{IN(ON)}$



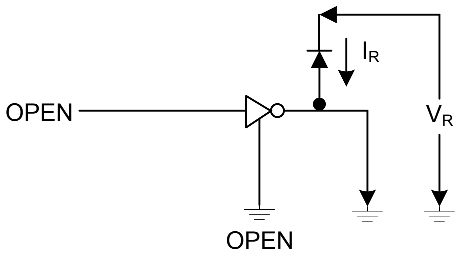
4. $I_{IN(OFF)}$



5. $V_{IN(ON)}$

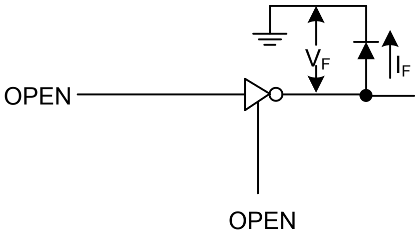


6. I_R

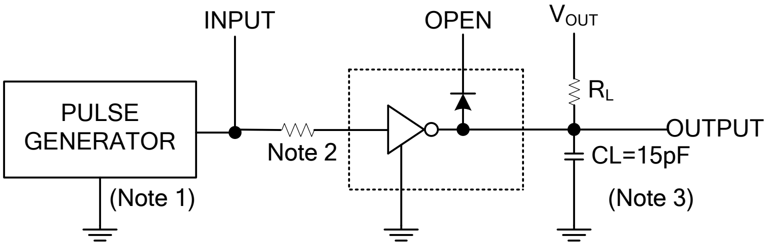


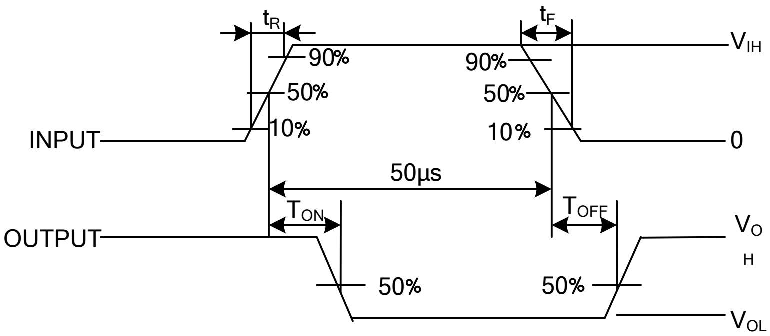
■ TEST CIRCUIT(Cont.)

7. V_F



8. t_{ON}, t_{OFF}





Note 1: Pulse width 50µs ,duty cycle 10%
Output impedance 50Ω t_R 5ns, t_F 10ns

Note 2: See below

INPUT CONDITION

TYPE NUMBER	R1	V_{IH}
ULN2003	0	3V

Note 3: C_L includes probe and jig capacitance

■ APPLICATION NOTES

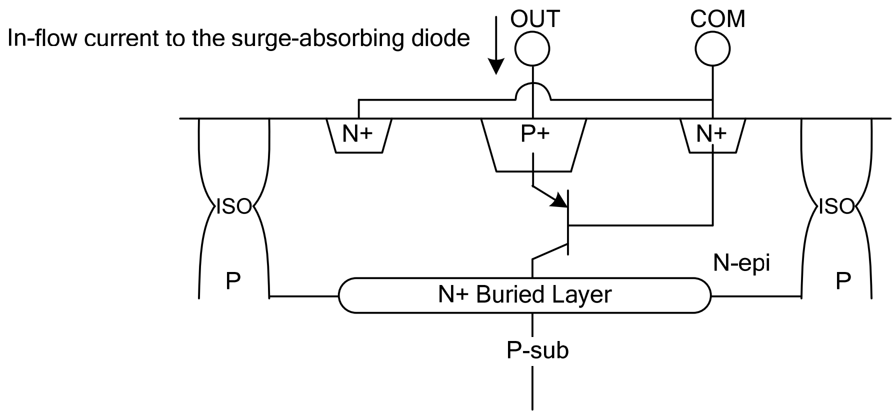
This UTC **ULN2003** does not include built-in protection circuits for over-current or over-voltage. If this IC is subjected to over-current or over-voltage, it may be destroyed. Hence, the utmost care must be taken when systems which incorporate this IC are designed. Utmost care is necessary in the design of the output line, COMMON and GND line since IC may be destroyed due to short-circuit between outputs, air contamination fault, or fault by improper grounding.

The UTC **ULN2003** is a darlington driver array, and can be directly coupled to a general logic circuit such as TTL or CMOS. Resistors are connected in series to each of the inputs to achieve a stable input current.

The load should be connected between the output and the power supply. To protect the IC from excessive swing voltage, the COMMON pin (Pin 9) should be connected to the power supply.

The UTC **ULN2003** can absorb the surge current because of the on-chip diode. The bottom Figure shows the configuration of the on-chip diode.

In the construction of the surge-absorbing diode, there is parasitic PNP, output pin for emitter, COMMON pin for base and the substrate (P-sub) for collector. When the diode is on, current flows from the output pin to the substrate. When using the surge-absorbing diode, appropriate measures should be taken for the thermal characteristics of the design considering the current. For example, when motor back-rush current or other conditions that can create continued surge current flow to the surge-absorbing diode, we strongly recommend connecting a Schottky barrier diode (or other type of diode with a low forward voltage) in parallel with the surge-absorbing diode to construct a bypass route for the surge current.



Construction of the Surge-Absorbing Diode

■ NOTICE ON PRODUCT USE

(1) The absolute maximum ratings of the IC are a set of ratings that must not be exceeded, even for a moment. Exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may cause injury by explosion or combustion.

(2) To ensure that a large current does not continuously flow in case of over current and/or IC failure, an appropriate power supply fuse should be used. The IC will fully breakdown under conditions that exceed its absolute maximum ratings. For example, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, careful settings, such as fuse capacity, fusing time and insertion circuit location, are required.

(3) If the design includes an inductive load such as a motor coil, the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF can cause device malfunction or breakdown, so a protection circuit need to be incorporated into the design. IC breakdown may cause injury, smoke or ignition. When the power supply is unstable, the build-in protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.

(4) Do not mount devices in the wrong orientation or incorrectly. Make sure that the positive and negative terminals of power supplies are connected properly. Otherwise, the current or power consumption may exceed the absolute maximum rating, and may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion. In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.

(5) Carefully select external components (such as inputs and negative feedback capacitors) and load components (such as speakers), for example, power amp and regulator. If there is a large amount of leakage current such as input or negative feedback condenser, the IC output DC voltage will increase. If this output voltage is connected to a speaker with low input withstand voltage, over-current or IC failure can cause smoke or ignition. (The over-current can cause smoke or ignition from the IC itself.) In particular, please pay attention to the Bridge Tied Load (BTL) connection type IC that inputs output DC voltage to a speaker directly.

■ POINTS TO REMEMBER ON PRODUCT USE

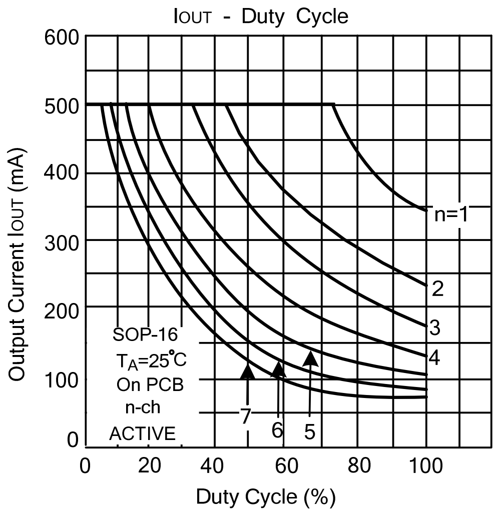
(1) Heat Radiation Design

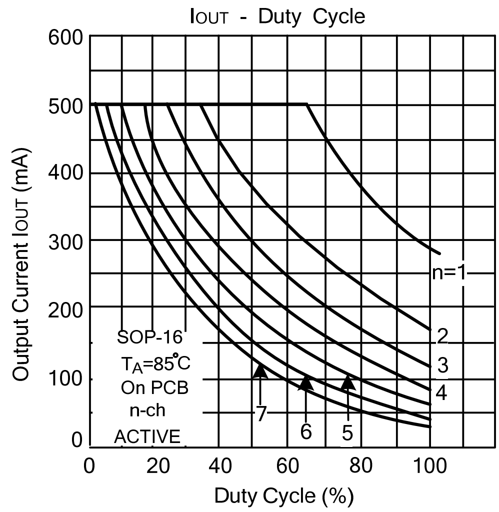
When IC is used with large current flow such as power amp, regulator or driver, the heat radiation consideration should be designed carefully, not to exceed the specified junction temperature (Tj) at any time and condition. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. Meanwhile, also should take into considerate the effect of IC heat radiation with peripheral components.

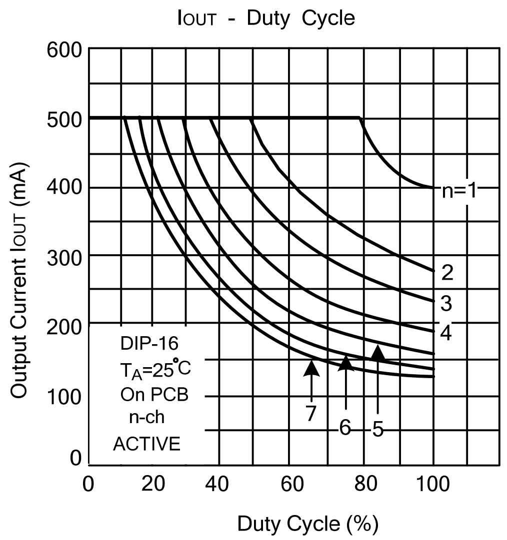
(2) Back-EMF

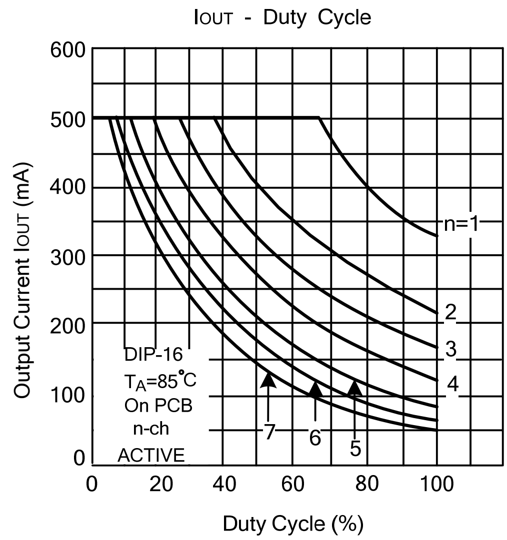
When a motor rotates in the reverse direction, stops or slows down abruptly, a current flow back to the motor's power supply due to the effect of back-EMF. The device's motor power supply and output pins might be exposed to conditions excessing absolute maximum ratings, when the current sink capability of the power supply is small. To avoid happening, take the effect of back-EMF into consideration in system design.

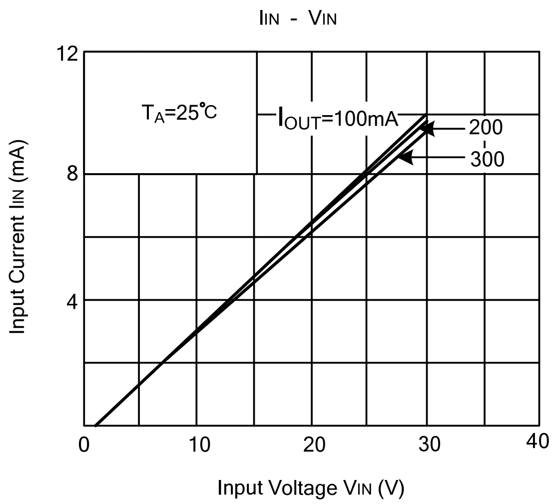
■ TYPICAL CHARACTERISTICS

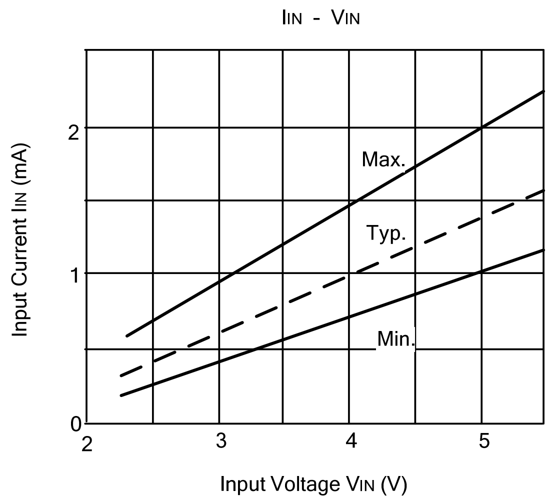




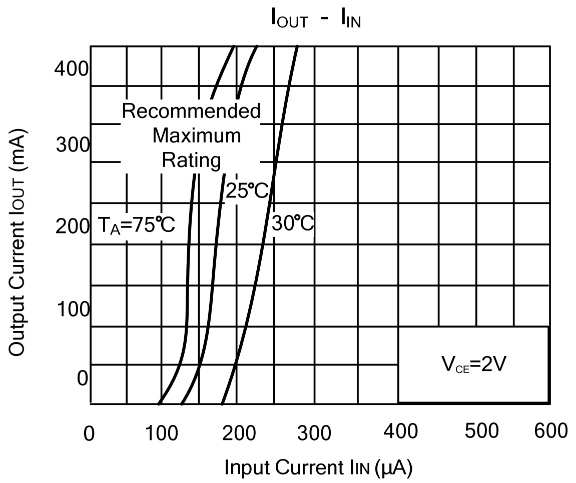


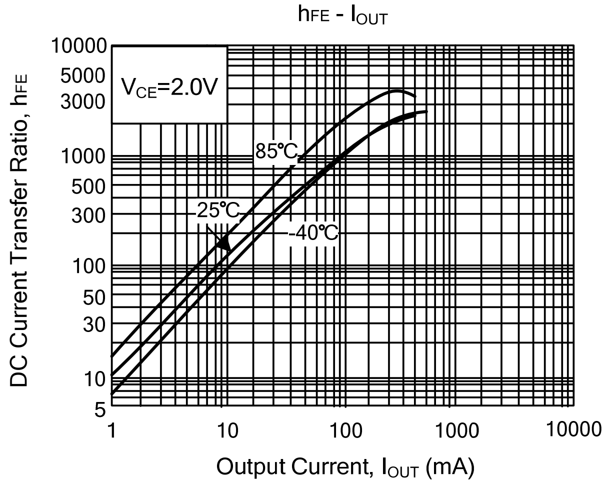


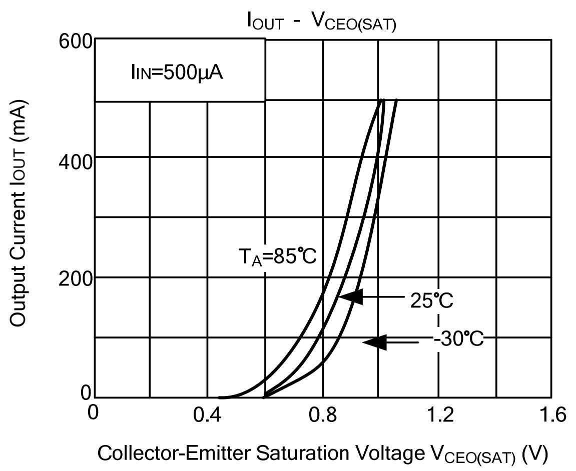


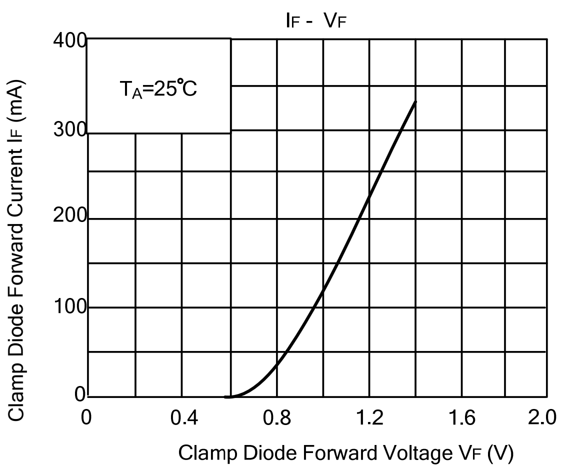


■ TYPICAL CHARACTERISTICS(Cont.)









■ TYPICAL CHARACTERISTICS(Cont.)