Photocouplers Infrared LED & Photo IC

TLP5231

1. Applications

- IGBT Gate Drivers
- MOSFET Gate Drivers
- Industrial Inverters
- AC Servos
- Photovoltaic (PV) Power Conditioning Systems
- Air Conditioner Inverters

2. General

The TLP5231 is a 2.5 A dual-output IGBT gate pre-drive photocoupler including highly integrated multi-functional IC that is housed in SO16L package having a long creepage and clearance. This photocoupler is suitable as a pre-driver to driver power devices via external p- and n- channel MOSFET as buffers.

The smart gate driver photocoupler includes functions of IGBT/power MOSFET desaturation detection, isolated fault status feedback, configurable soft gate turn-off, and under voltage lockout (UVLO).

The TLP5231 consists of two infrared light-emitting diodes (LEDs) and two high-gain and high-speed light-receiving IC chips. Thereby, they realize the control of output current and the feedback function of the fault signal while keeping a insulation between a primary side and secondary side electrically.

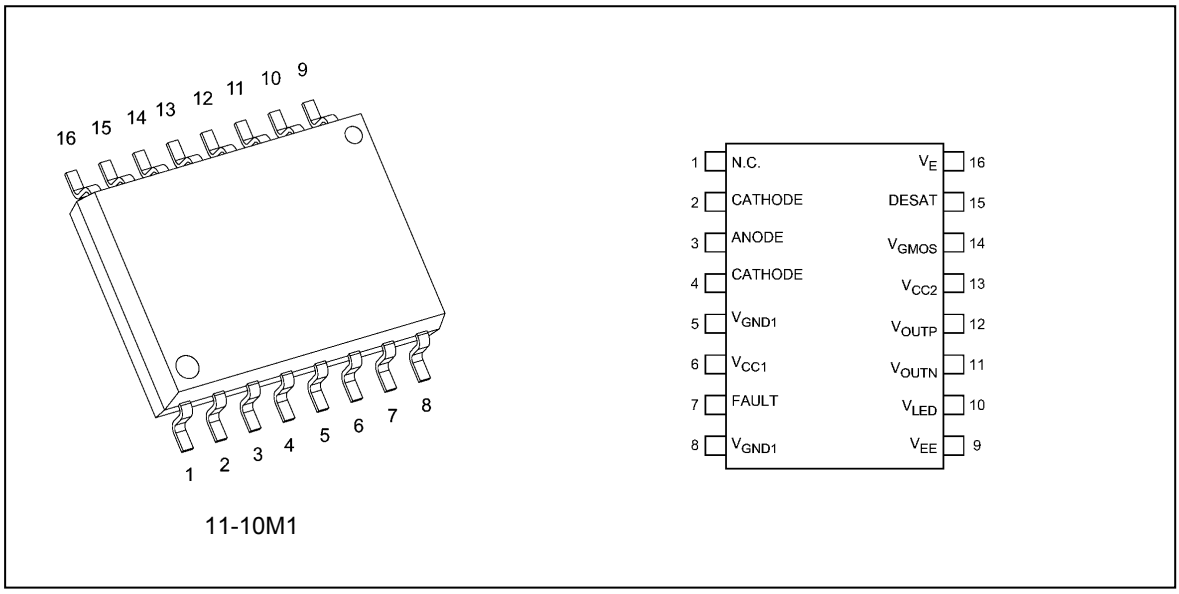
3. Features

(1) Output peak current: ±2.5 A (max)
(2) Operating temperature: -40 to 110 ℃
(3) Threshold input current: 3.5 mA (max)
(4) Propagation delay time: 300 ns (max)
(5) Common-mode transient immunity: ±25 kV/μs (min)
(6) Isolation voltage: 5000 Vrms (min)
(7) Dual output drive for external complementary type MOS buffer.
(8) Under Voltage Lock-Out protection for positive and negative gate power supply.
(9) Safety standards
UL-recognized: UL 1577, File No.E67349
cUL-recognized: CSA Component Acceptance Service No.5A File No.E67349
VDE-approved: EN 60747-5-5, EN 62368-1 **(Note 1)**
CQC-approved: GB4943.1, GB8898 Japan Factory

Note 1: When a VDE approved type is needed, please designate the **Option (D4)**.

Start of commercial production
2020-01

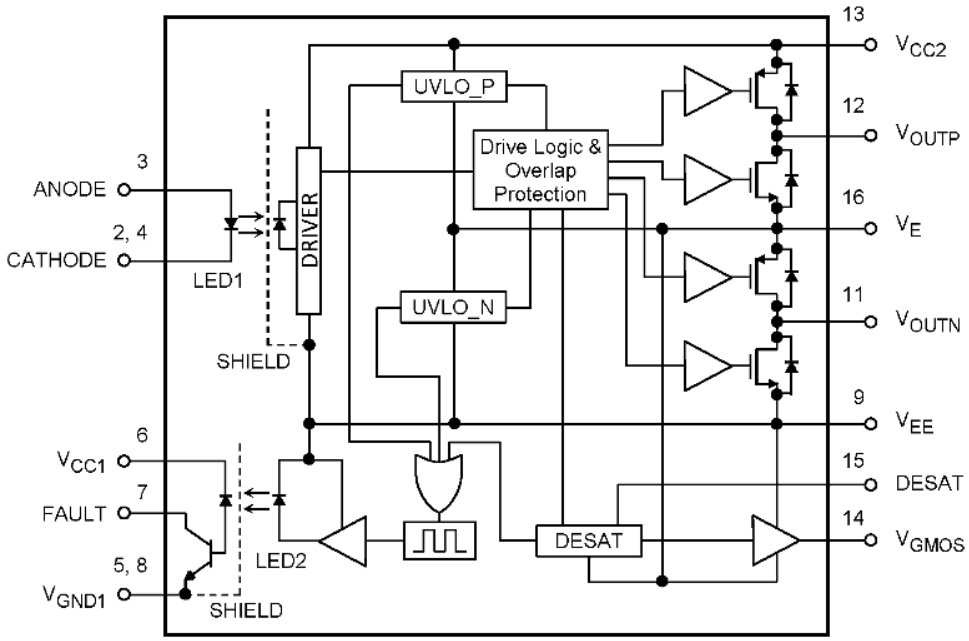
4. Packaging and Pin Assignment



4.1. Pin Description

Pin No.	Symbol	Description
1	N.C.	No connection
2	CATHODE	Cathode
3	ANODE	Anode
4	CATHODE	Cathode
5	V_{GND1}	Input side ground
6	V_{CC1}	Positive input supply voltage
7	FAULT	Fault output
8	V_{GND1}	Input side ground
9	V_{EE}	Negative output supply voltage
10	V_{LED}	Not connect, for testing only
11	V_{OUTN}	Low side voltage output
12	V_{OUTP}	High side voltage output
13	V_{CC2}	Positive output supply voltage
14	V_{GMOS}	External MOSFET control pin
15	DESAT	Short-circuit detection of The Desat terminal
16	V_E	Common output power supply terminal (emitter or source terminal of power device)

5. Internal Circuit (Note)



Note: A 10μF bypass capacitor must be connected between pins 9 and 13, and A 1μF bypass capacitor must be connected between pins 13 and 16, and pins 9 and 16.
A 0.33μF bypass capacitor must be connected between pins 6 and 5, or pins 6 and 8.

6. Principle of Operation

6.1. Truth Table

Input current I_F	Under Voltage Lock-Out UVLO_P, UVLO_N	DESAT function	FAULT pin7 OUTPUT	V_{OUTP}	V_{OUTN}	V_{GMOS}
X	Active	Not active	H (V_{CC1})	H (V_{CC2})	H (V_E)	H (V_E)
ON	Not active	Active (with DESAT fault)	H (V_{CC1})	H (V_{CC2})	L (V_{EE})	H (V_E)
ON	Not active	Active (without DESAT fault)	L (V_{GND1})	L (V_E)	L (V_{EE})	L (V_{EE})
OFF	Not active	Not active	L (V_{GND1})	H (V_{CC2})	H (V_E)	L (V_{EE})

6.2. Mechanical Parameters

Characteristics	Dimensions	Unit
Creepage distances	8.0 (min)	mm
Clearance distances		
Internal isolation thickness	0.4 (min)	

7. Absolute Maximum Ratings (Note) (Unless otherwise specified, T_a = 25 °C)

	Characteristics		Symbol	Note	Rating	Unit
LED (controller side)	Input forward current		I_F		25	mA
	Input forward current derating	($T_a \geq$ 95 °C)	$\Delta I_F/\Delta T_a$		-0.84	mA/°C
	Peak transient input forward current		I_{FPT}	(Note 1)	1	A
	Peak transient input forward current derating	($T_a \geq$ 95 °C)	$\Delta I_{FPT}/\Delta T_a$	(Note 2)	-34	mA/°C
	Input reverse voltage		V_R		5	V
	Positive input supply voltage		V_{CC1}		-0.5 to 7	V
	FAULT output current		I_{FAULT}		8	mA
	FAULT terminal voltage		V_{FAULT}		-0.5 to V_{CC1}	V
	Input power dissipation		P_D		150	mW
	Input power dissipation derating	($T_a \geq$ 95 °C)	$\Delta P_D/\Delta T_a$	(Note 2)	-5.0	mW/°C
Detector (gate driver side)	Peak high-level output current	(T_a = -40 to 110 °C)	I_{OPH}	(Note 3)	-2.5	A
	Peak low-level output current	(T_a = -40 to 110 °C)	I_{OPL}	(Note 3)	+2.5	A
	Total output supply voltage		(V_{CC2}-V_{EE})	(Note 4)	-0.5 to 35	V
	Negative output supply voltage		(V_E-V_{EE})	(Note 4)	-0.5 to 17	V
	Positive output supply voltage		(V_{CC2}-V_E)	(Note 4)	-0.5 to 30	V
	High side output voltage		$V_{OUTP(Peak)}$		V_E - 0.5 to V_{CC2} + 0.5	V
	Low side output voltage		$V_{OUTN(Peak)}$		V_{EE} - 0.5 to V_E + 0.5	V
	DESAT voltage		V_{DESAT}		V_E - 0.5 to V_{CC2} + 0.5	V
	V_{GMOS} voltage		V_{GMOS}		V_{EE} - 0.5 to V_E + 0.5	V
	Output power dissipation		P_O		410	mW
	Output power dissipation derating	($T_a \geq$ 95 °C)	$\Delta P_O/\Delta T_a$	(Note 2)	-14.0	mW/°C
Common	Operating temperature		T_{opr}		-40 to 110	°C
	Storage temperature		T_{stg}		-55 to 125	°C
	Lead soldering temperature	(10 s)	T_{sol}	(Note 5)	260	°C
	Isolation voltage	(AC, 60 s, R.H. ≤ 60 %)	BV_S	(Note 6)	5000	Vrms

Note: Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings.
Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook ("Handling Precautions"/"Derating Concept and Methods") and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

Note 1: Pulse width (PW) ≤ 1μs, 300pps

Note 2: Mounting on the substrate made in accordance with JEDEC JESD51-7.

Note 3: Exponential waveform. Pulse width ≤ 0.2 μs, f ≤ 15 kHz, V_{CC2} = 15 V

Note 4: Positive and Negative power supply (V_{CC2}/V_{EE}) must be used in the gate drive circuit.

Note 5: ≥ 2 mm below seating plane.

Note 6: This device is considered as a two-terminal device: Pins 1 through 8 are shorted together, and pins 9 through 16 are shorted together.

8. Recommended Operating Conditions (Note)

Characteristics	Symbol	Note	Min	Typ.	Max	Unit
Total output supply voltage	(V_{CC2}-V_{EE})	(Note 1)	21.5	—	30	V
Negative output supply voltage	(V_E-V_{EE})	(Note 1)	-15	—	-6.5	V
Positive output supply voltage	(V_{CC2}-V_E)	(Note 1)	15	—	30 - (V_E - V_{EE})	V
Positive input supply voltage	V_{CC1}		3.3	—	5.5	V
Input on-state current	$I_{F(ON)}$	(Note 2)	5.3	—	12	mA
Input off-state voltage	$V_{F(OFF)}$	(Note 2)	0	—	0.8	V

Note: The recommended operating conditions are given as a design guide necessary to obtain the intended performance of the device. Each parameter is an independent value. When creating a system design using this device, the electrical characteristics specified in this data sheet should also be considered.

Note: A ceramic capacitor (10 μF) must be connected between pins 9 (V_{EE}) and 13 (V_{CC2}), and a ceramic capacitor (1 μF) must be connected between pins 13 (V_{CC2}) and 16 (V_E), and pins 9 (V_{EE}) and 16 (V_E) to stabilize the operation of the high gain linear amplifier. Failure to provide the bypassing may impair the switching property. The bypass capacitor should be placed within 1 cm of each pin.

Note 1: If the rising slopes of V_{CC2} and V_{EE} are so steep, the internal circuit operation may not be stable. In that case please design the slopes that V_{CC2} and V_{EE} go up to become 0.1 V/μs or less.

Note 2: The rise and fall times of the input on-current should be less than 0.5 μs.

9. Electrical Characteristics

9.1. Electrical Characteristics (Note)
(Unless otherwise specified, T_a = -40 to 110 °C, V_{CC2} - V_E = 15 V, V_E - V_{EE} = 8 V)

Characteristics	Symbol	Note	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input forward voltage	V_F			I_F = 10 mA, T_a = 25 °C	1.45	—	1.7	V
Input reverse current	I_R			V_R = 5 V	—	—	10	μA
Input capacitance	C_t			V = 0 V, f = 1 MHz, T_a = 25 °C	—	60	—	pF
FAULT low level output voltage	V_{FAULTL}			V_{DESAT} = 0 V, R_F = 10 kΩ, C_F = 1 nF, V_{CC1} = 3.3 or 5 V	—	0.1	0.25	V
FAULT high level output voltage	V_{FAULTH}			V_{DESAT} = Open, R_F = 10 kΩ, C_F = 1 nF, V_{CC1} = 3.3 or 5 V	—	V_{CC1}	—	
FAULT low level output current	I_{FAULTL}			V_{FAULT} = 0.15 V, V_{CC1} = 3.3 or 5 V	—	1.2	—	mA
FAULT high level output current	I_{FAULTH}			V_{FAULT} = V_{CC1} = 3.3 or 5 V	—	0.01	1	μA
V_{OUTP} high level output current	I_{OUTPH}	(Note 1)	Fig.13.1.1	V_{CC2} - V_{OUTP} = 7 V	—	—	-1.0	A
V_{OUTP} low level output current	I_{OUTPL}	(Note 1)	Fig.13.1.2	V_{OUTP} - V_E = 7 V, I_F = 8 mA	1.0	—	—	
V_{OUTN} high level output current	I_{OUTNH}	(Note 1)	Fig.13.1.3	V_E - V_{OUTN} = 7 V	—	—	-1.0	
V_{OUTN} low level output current	I_{OUTNL}	(Note 1)	Fig.13.1.4	V_{OUTN} - V_{EE} = 7 V, I_F = 8 mA	1.0	—	—	
V_{OUTP} high level output resistance	R_{OUTPH}	(Note 1)	Fig.13.1.5	I_{OUTP} = -1.0 A, V_F = 0 V	—	1.6	4.4	Ω
V_{OUTP} low level output resistance	R_{OUTPL}	(Note 1)	Fig.13.1.6	I_{OUTP} = 1.0 A, I_F = 8 mA	—	1.2	3.3	
V_{OUTN} high level output resistance	R_{OUTNH}	(Note 1)	Fig.13.1.7	I_{OUTN} = -1.0 A, V_F = 0 V	—	1.9	5.0	
V_{OUTN} low level output resistance	R_{OUTNL}	(Note 1)	Fig.13.1.8	I_{OUTN} = 1.0 A, I_F = 8 mA	—	1.0	3.3	
V_{OUTP} high level output voltage	V_{OUTPH}		Fig.13.1.5	I_{OUTP} = -100 mA, V_F = 0 V	V_{CC2} - 0.43	V_{CC2} - 0.14	—	V
V_{OUTP} low level output voltage	V_{OUTPL}		Fig.13.1.6	I_{OUTP} = 100 mA, I_F = 8 mA	—	V_E + 0.1	V_E + 0.32	
V_{OUTN} high level output voltage	V_{OUTNH}		Fig.13.1.7	I_{OUTN} = -100 mA, V_F = 0 V	V_E - 0.4	V_E - 0.17	—	
V_{OUTN} low level output voltage	V_{OUTNL}		Fig.13.1.8	I_{OUTN} = 100 mA, I_F = 8 mA	—	V_{EE} + 0.1	V_{EE} + 0.3	

Note: All typical values are at T_a = 25 °C.

Note: C_F means smoothing capacitor.It attaches between pin 7 and pin 5, or pin 7 and pin 8 certainly.

Note 1: I_O application time ≤ 10 μs; single pulse.

9.2. Electrical Characteristics (Note)
(Unless otherwise specified, T_a = -40 to 110 °C, V_{CC2} - V_E = 15 V, V_E - V_{EE} = 8 V)

Characteristics	Symbol	Note	Test Circuit	Test Condition	Min	Typ.	Max	Unit
V_{GMOS} high level output current	I_{OUTGH}		Fig.13.1.9	V_E - V_{GMOS} = 8 V, I_F = 8 mA, DESAT = Open	—	—	-105	mA
V_{GMOS} low level output current	I_{OUTGL}		Fig.13.1.10	V_{GMOS} - V_{EE} = 8 V, V_F = 0 V, DESAT = Open	90	—	—	
V_{GMOS} high level output resistance	R_{OUTGH}		Fig.13.1.11	I_{OUTG} = -80 mA, I_F = 8 mA	—	10	30	Ω
V_{GMOS} low level output resistance	R_{OUTGL}		Fig.13.1.12	I_{OUTG} = 80 mA, V_F = 0 V, DESAT = Open	—	4	10	
V_{GMOS} high level output voltage	V_{OUTGH}		Fig.13.1.11	I_{OUTG} = -1 mA, I_F = 8 mA, DESAT = Open	—	V_E	—	V
V_{GMOS} low level output voltage	V_{OUTGL}		Fig.13.1.12	I_{OUTG} = 1 mA, V_F = 0 V, DESAT = Open	—	V_{EE}	—	
High level supply current (V_{CC2})	I_{CC2H}		Fig.13.1.13	V_F = 0 V, no load	—	5.8	10.2	mA
Low level supply current (V_{CC2})	I_{CC2L}		Fig.13.1.14	I_F = 8 mA, no load	—	6.2	10.2	
High level supply current (V_{EE})	I_{EEH}		Fig.13.1.13	V_F = 0 V, no load	-9.2	-5.2	—	
Low level supply current (V_{EE})	I_{EEL}		Fig.13.1.14	I_F = 8 mA, no load	-9.2	-5.5	—	
Threshold input current (H/L)	I_{FHL}		Fig.13.1.15	V_{OUTP} - V_E < 5 V, V_{OUTN} - V_{EE} < 1 V	—	1	3.5	
Threshold input voltage (L/H)	V_{FLH}			V_{OUTP} - V_E > 5 V, V_{OUTN} - V_{EE} > 1 V	0.8	—	—	V
UVLO_P threshold (V_{CC2}-V_E)	V_{UVLOP+}	(Note 1), (Note 2)		I_F = 8 mA, V_{OUTP} - V_E < 5 V	12	13	14	
UVLO_P threshold (V_{CC2}-V_E)	V_{UVLOP-}	(Note 1)		I_F = 8 mA, V_{OUTP} - V_E > 5 V	11	12	13	
UVLO_P hysteresis (V_{CC2}-V_E)	V_{UVLOP_HYS}	(Note 1)		V_{UVLOP+} - V_{UVLOP-}	—	1	—	
UVLO_N threshold (V_E-V_{EE})	V_{UVLON+}	(Note 1), (Note 2)		I_F = 8 mA, V_{OUTN} - V_{EE} < 1 V	-6	-5.3	-5	
UVLO_N threshold (V_E-V_{EE})	V_{UVLON-}	(Note 1)		I_F = 8 mA, V_{OUTN} - V_{EE} > 1 V	-5.7	-5.0	-4.7	
UVLO_N hysteresis (V_E-V_{EE})	V_{UVLON_HYS}	(Note 1)		V_{UVLON+} - V_{UVLON-}	—	0.3	—	
DESAT threshold	V_{DESAT}	(Note 2)		V_{CC2} - V_E > V_{UVLOP-}, V_E - V_{EE} > V_{UVLON-}	7.5	8.0	9.0	
Blanking capacitor charging current	I_{CHG}		Fig.13.1.16	V_{DESAT} = 2 V	-0.82	-0.54	-0.29	mA
Blanking capacitor discharging voltage	V_{DSCHG}			I_{DSCHG} = 10 mA	—	1.1	3.0	V

Note: All typical values are at T_a = 25 °C.

Note 1: V_{UVLOP+} is the increasing of V_{CC2}-V_E. V_{UVLOP-} is the decreasing of V_{CC2}-V_E.
15V is the recommended minimum V_{CC2} to ensure adequate margin in excess of the maximum V_{UVLOP+}.
V_{UVLON+} is the increasing of V_E-V_{EE}. V_{UVLON-} is the decreasing of V_E-V_{EE}.
-6.5V is the recommended maximum V_{EE} to ensure adequate margin in excess of the minimum V_{UVLON+}.

Note 2 :Once V_{OUTP} and V_{OUTN} are allowed to go low, the DESAT detection feature will be the primary source of power device protection.
In order for to DESAT function, un-activating of UVLO is required.(V_{CC2}-V_E>V_{UVLOP}, V_E-V_{EE}>V_{UVLON})

10. Isolation Characteristics (Unless otherwise specified, T_a = 25 °C)

Characteristics	Symbol	Note	Test Condition	Min	Typ.	Max	Unit
Total capacitance (input to output)	C_S	(Note 1)	V_S = 0 V, f = 1 MHz	—	1.0	—	pF
Isolation resistance	R_S	(Note 1)	V_S = 500 V, R.H. ≤ 60 %	10^{12}	10^{14}	—	Ω
Isolation voltage	BV_S	(Note 1)	AC, 60 s	5000	—	—	Vrms

Note 1: This device is considered as a two-terminal device: Pins 1 through 8 are shorted together, and pins 9 through 16 are shorted together.

11. Switching Characteristics

11.1. Switching Characteristics (Note)
(Unless otherwise specified, T_a = -40 to 110 °C, V_{CC2} - V_E = 15 V, V_E - V_{EE} = 8 V)

Characteristics	Symbol	Note	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Propagation delay time (L/H)	t_{pLH}	(Note 1)	Fig.13.1.17	I_F = 8→0 mA, C_P = C_N = 4 nF, f = 20 kHz, duty = 50 %	100	200	300	ns
Propagation delay time (H/L)	t_{pHL}			I_F = 0→8 mA, C_P = C_N = 4 nF, f = 20 kHz, duty = 50 %	100	200	300	
Pulse width distortion	$\lvert t_{pHL} - t_{pLH} \rvert$			I_F = 0←→8 mA, C_P = C_N = 4 nF, f = 20 kHz, duty = 50 %	—	—	150	
Propagation delay skew (device to device)	t_{psk}	(Note 1), (Note 2)			-200	—	200	
V_{OUTP} rise time at LED-OFF (90 %)	t_{DP}	(Note 1)		I_F = 8→0 mA, C_P = C_N = 4 nF, f = 20 kHz, duty = 50 %	50	150	250	
V_{OUTN} fall time at LED-ON (10%)	t_{DN}			I_F = 0→8 mA, C_P = C_N = 4 nF, f = 20 kHz, duty = 50 %	50	150	250	
Outputs non-overlap time (L/H)	t_{NLH}			I_F = 8→0 mA, C_P = C_N = 4 nF, f = 20 kHz, duty = 50 %	—	60	—	
Outputs non-overlap time (H/L)	t_{NHL}			I_F = 0→8 mA, C_P = C_N = 4 nF, f = 20 kHz, duty = 50 %	—	50	—	
Rise time of V_{OUTP}	t_{PR}			I_F = 8→0 mA, C_P = C_N = 4 nF, f = 20 kHz, duty = 50 %	—	50	—	
Fall time of V_{OUTP}	t_{PF}			I_F = 0→8 mA, C_P = C_N = 4 nF, f = 20 kHz, duty = 50 %	—	50	—	
Rise time of V_{OUTN}	t_{NR}			I_F = 8→0 mA, C_P = C_N = 4 nF, f = 20 kHz, duty = 50 %	—	50	—	
Fall time of V_{OUTN}	t_{NF}			I_F = 0→8 mA, C_P = C_N = 4 nF, f = 20 kHz, duty = 50 %	—	40	—	

Note: All typical values are at T_a = 25 °C.
C_P and C_N mean the gate capacitance of an external MOSFET buffer.

Note 1: Input signal duty = 50 %, t_r = t_f = 5 ns or less

Note 2: The propagation delay skew, t_{psk}, is equal to the magnitude of the worst-case difference in t_{pHL} and/or t_{pLH} that will be seen between units at the same given conditions (supply voltage, input current, temperature, etc).

11.2. Switching Characteristics (Note)
(Unless otherwise specified, T_a = -40 to 110 °C, V_{CC2} - V_E = 15 V, V_E - V_{EE} = 8 V)

Characteristics	Symbol	Note	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Propagation delay time from DESAT threshold to 50% of high V_{GMOS}	t_1	(Note 1)	Fig.13.1.18	C_P = C_N = 4 nF, C_G = 1 nF, f = 100 Hz, duty = 50 %, I_F = 8 mA, C_{BLANK} = 200 pF, V_{DESAT} = 8.0 V	—	450	750	ns
Propagation delay time from DESAT threshold to 50% of high V_{OUTP}	t_2				—	380	700	
Propagation delay time from DESAT threshold to 50% of high V_{FAULT}	t_3			R_F = 10 kΩ, C_F = 1 nF, V_{CC1} = 3.3 or 5 V, f = 100 Hz, duty = 50 %, I_F = 8 mA	—	8	20	μs
Propagation delay time from 50% V_{GMOS} to 50% of V_{OUTN}	t_4			C_P = C_N = 4 nF, C_G = 1 nF, f = 100 Hz, duty = 50 %, I_F = 8 mA	—	45	—	ns
DESAT Mute time	t_{MUTE}	(Note 2)		I_F = 8 mA	0.68	1.1	1.7	ms
DESAT leading edge blanking time	t_{DESAT} (LEB)	(Note 3)		—	—	580	—	ns
DESAT filter time	t_{DESAT} (FILTER)	(Note 4)		R_{DESAT} = 100 Ω, V_{in} = 10 V, PW = 1 μs, monitor: V_{OUTP}, V_{GMOS}	—	290	—	
High-level common-mode transient immunity	CM_H	(Note 5)	Fig.13.1.19, Fig.13.1.21	T_a = 25 °C, $\|V_{CM}\|$ = 1500 V_{p-p}, V_{CC1} = 5 V (I_F = 0 mA), R_{in} = 220 Ω (with split resistors)	±25	—	—	kV/μs
Low-level common-mode transient immunity	CM_L	(Note 6)	Fig.13.1.20, Fig.13.1.22	T_a = 25 °C, $\|V_{CM}\|$ = 1500 V_{p-p}, V_{CC1} = 5 V (I_F = 8 mA), R_{in} = 220 Ω (with split resistors)	±25	—	—	

Note: All typical values are at T_a = 25 °C.
C_G means the external MOSFET gate capacitance for soft gate turn-off.

Note 1: Input signal duty = 50 %, t_r = t_f = 5 ns or less

Note 2: Automatic reset time from protected operation.If the input voltage of a DESAT pin exceeds V_{DESAT}, V_{OUTP} moves to high level, V_{OUTN} set to low level, V_{GMOS} moves to high level and FAULT moves to high level, then protected operation will start. If a gate input signal returns to a low level, automatic reset of the protected operation will be carried out after t_{MUTE}. Refer to Fig. 13.2.2 and Fig. 13.2.3.

Note 3: Disabling time for incorrect detection prevention in case a gate control signal inputs.Refer to Fig. 13.2.2.

Note 4: Disabling time for incorrect detection prevention when the input voltage to a DESAT pin exceeds V_{DESAT}. ($t_{DESAT(FILTER)}$ < t_1, t_2)

Note 5: CM_H is the maximum rate of fall of the common mode voltage that can sustained with the output voltage in the logic high state (V_{OUTP} - V_E > 12 V, V_{OUTN} - V_{EE} > 5 V or V_{FAULT} > 2 V).

Note 6: CM_L is the maximum rate of rise of the common mode voltage that can sustained with the output voltage in the logic low state (V_{OUTP} - V_E < 1 V, V_{OUTN} - V_{EE} < 1 V or V_{FAULT} < 0.8 V).

12. Application Information

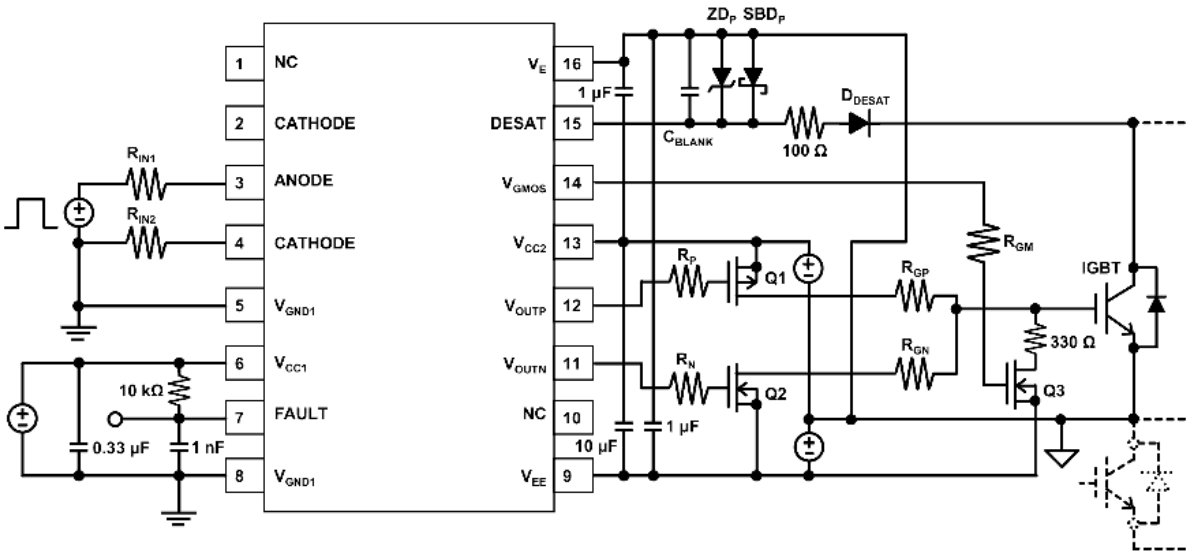


Fig. 12.1 Recommended Application Circuit

Note: The gate circuit of a power device requires both a positive power supply (V_{CC2}) and a negative power supply (V_{EE}).
Attach external P channel MOSFET and N channel MOSFET to a V_{OUTP} pin and a V_{OUTN} pin.
Refer to the connection of pin 14, pin 15, and pin 16 for a DESAT detection function and an over-current protection soft gate turn-off function.
A smoothing capacitor is absolutely attached between pin 7 and pin 5, or pin 7 and pin 8.

13. Reference Drawings

13.1. Test Circuits

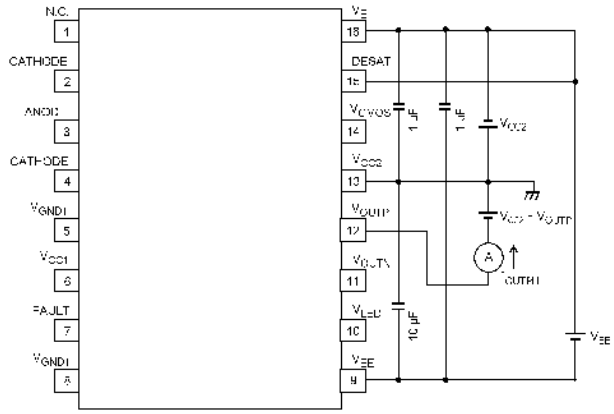


Fig. 13.1.1 I_{OUTPH} Test Circuit

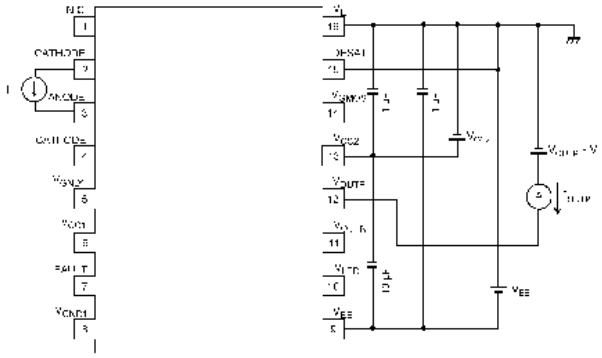


Fig. 13.1.2 I_{OUTPL} Test Circuit

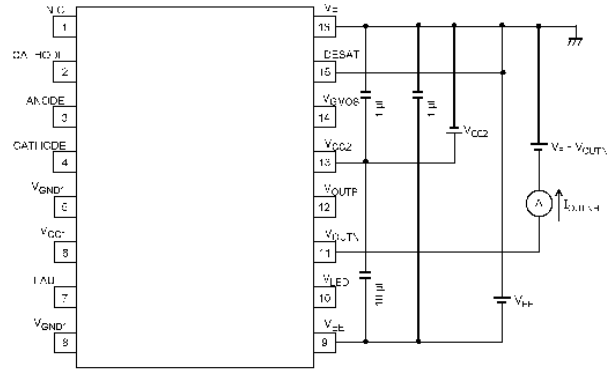


Fig. 13.1.3 I_{OUTNH} Test Circuit

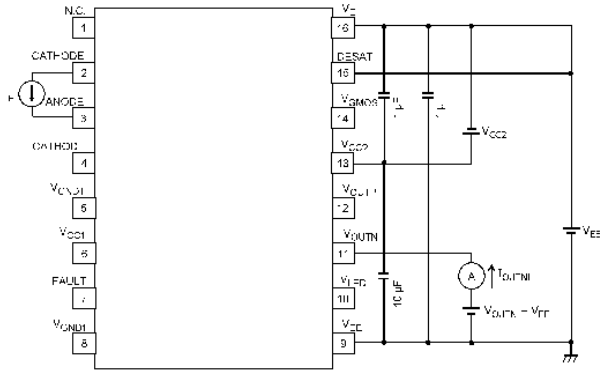


Fig. 13.1.4 I_{OUTNL} Test Circuit

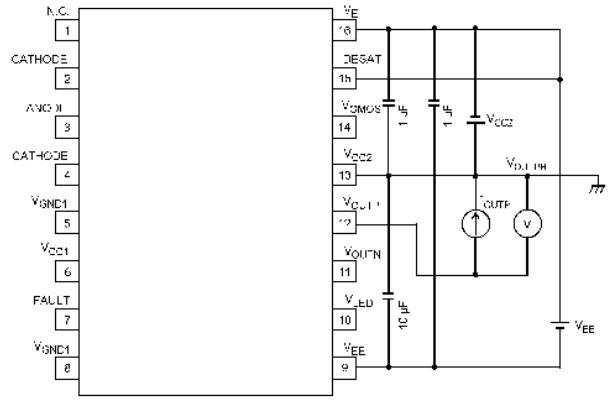


Fig. 13.1.5 V_{OUTPH}, R_{OUTPH} Test Circuit

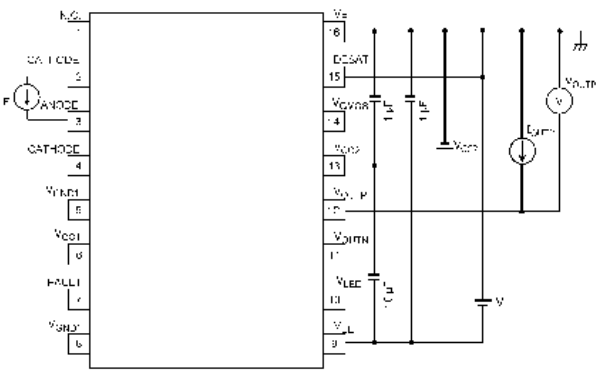


Fig. 13.1.6 V_{OUTPL}, R_{OUTPL} Test Circuit

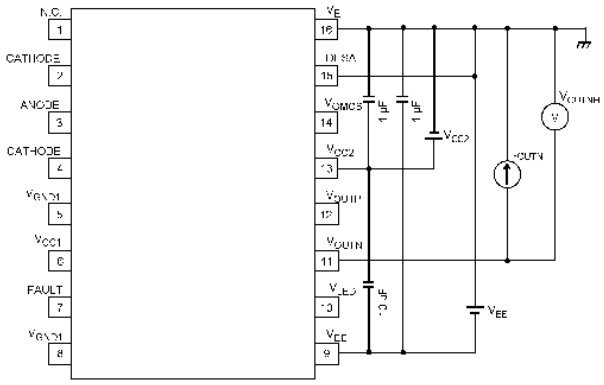


Fig. 13.1.7 V_{OUTNH}, R_{OUTNH} Test Circuit

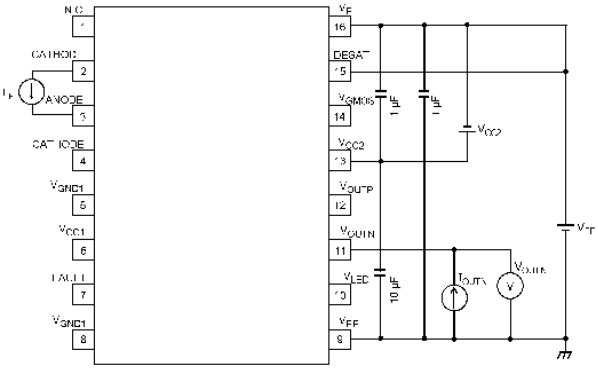


Fig. 13.1.8 V_{OUTNL}, R_{OUTNL} Test Circuit

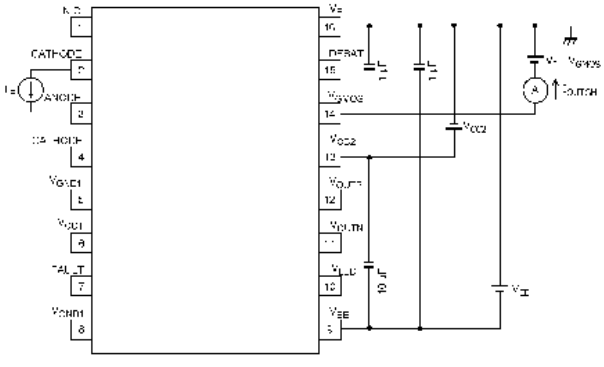


Fig. 13.1.9 I_{OUTGH} Test Circuit

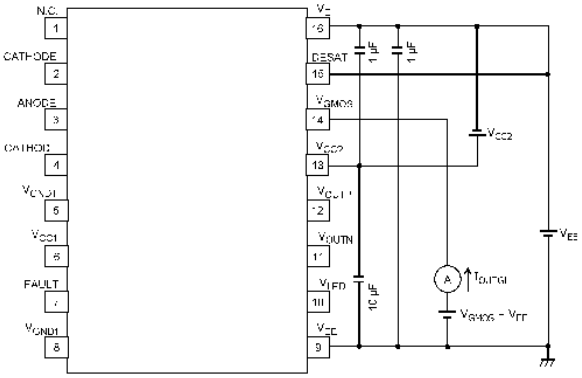


Fig. 13.1.10 I_{OUTGL} Test Circuit

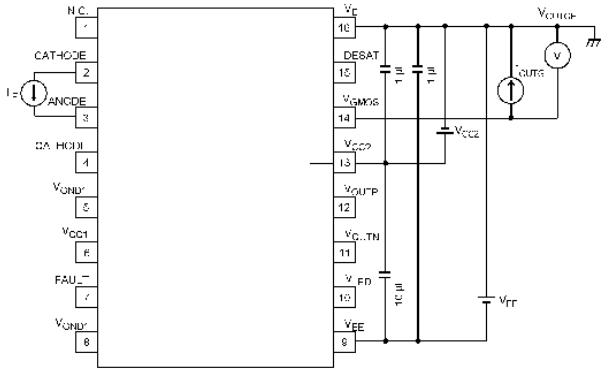


Fig. 13.1.11 V_{OUTGH}, R_{OUTGH} Test Circuit

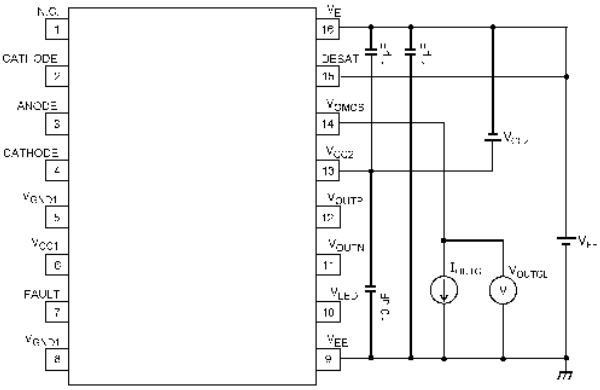


Fig. 13.1.12 V_{OUTGL}, R_{OUTGL} Test Circuit

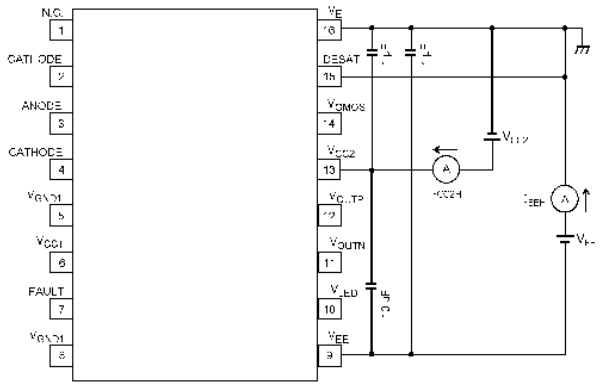


Fig. 13.1.13 I_{CC2H}, I_{EEH} Test Circuit

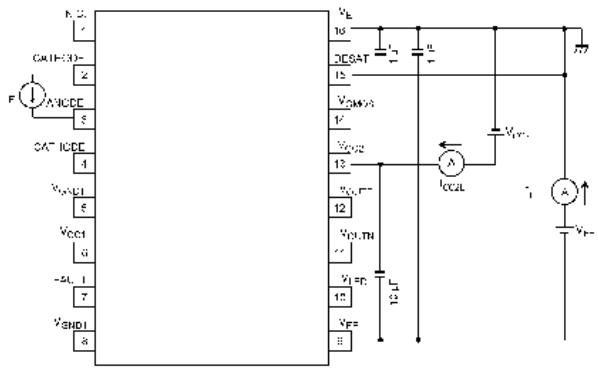


Fig. 13.1.14 I_{CC2L}, I_{EEL} Test Circuit

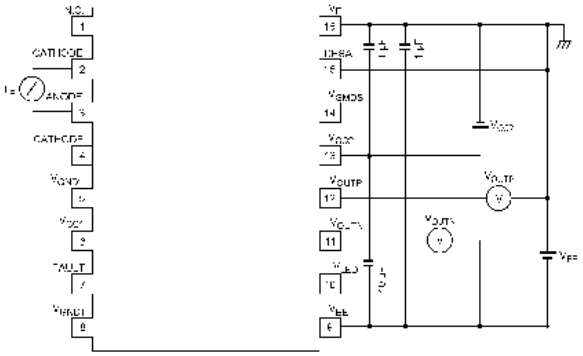


Fig. 13.1.15 I_{FHL}, I_{FLH} Test Circuit

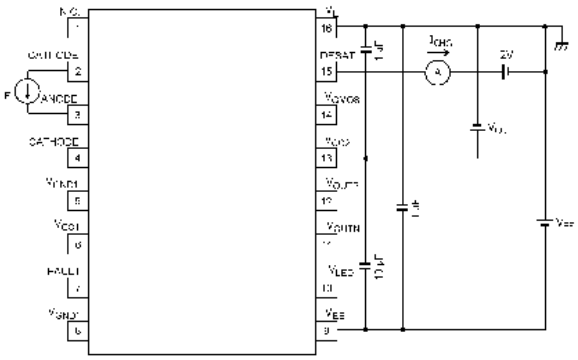


Fig. 13.1.16 I_{CHG} Test Circuit

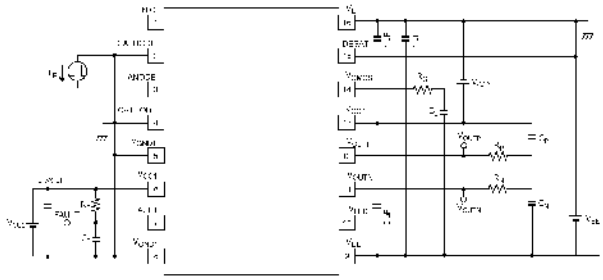


Fig. 13.1.17 t_{pLH}, t_{pHL}, t_{NLH}, t_{NHL}, t_{DP}, t_{DN}, t_{PR}, t_{PF}, t_{NR}, t_{NF} Test Circuit

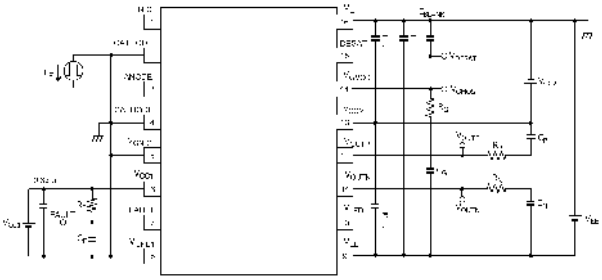


Fig. 13.1.18 t_1, t_2, t_3, t_4, t_{MUTE} Test Circuit

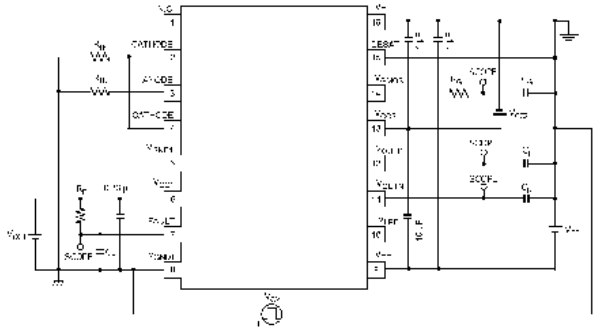


Fig. 13.1.19 CM_H Refer to V_E Test Circuit (Gate Output: OFF)

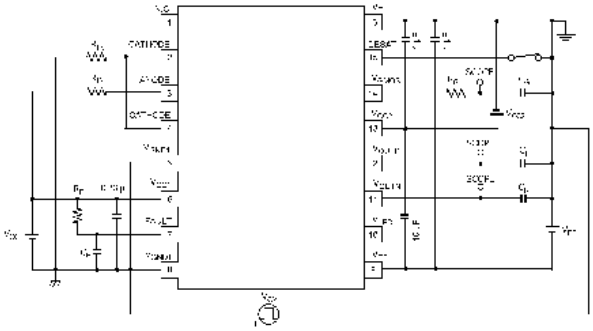


Fig. 13.1.20 CM_L Refer to V_E Test Circuit (Gate Output: ON)

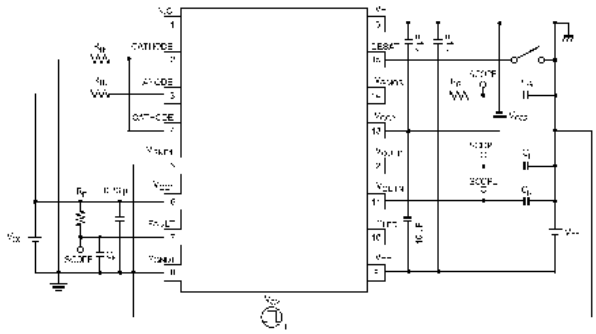


Fig. 13.1.21 CM_H Refer to V_{GND1} Test Circuit (Fault Output: HIGH)

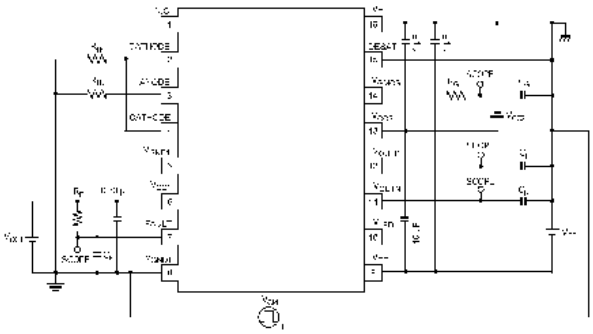


Fig. 13.1.22 CM_L Refer to V_{GND1} Test Circuit (Fault Output: LOW)

13.2. Timing Diagrams

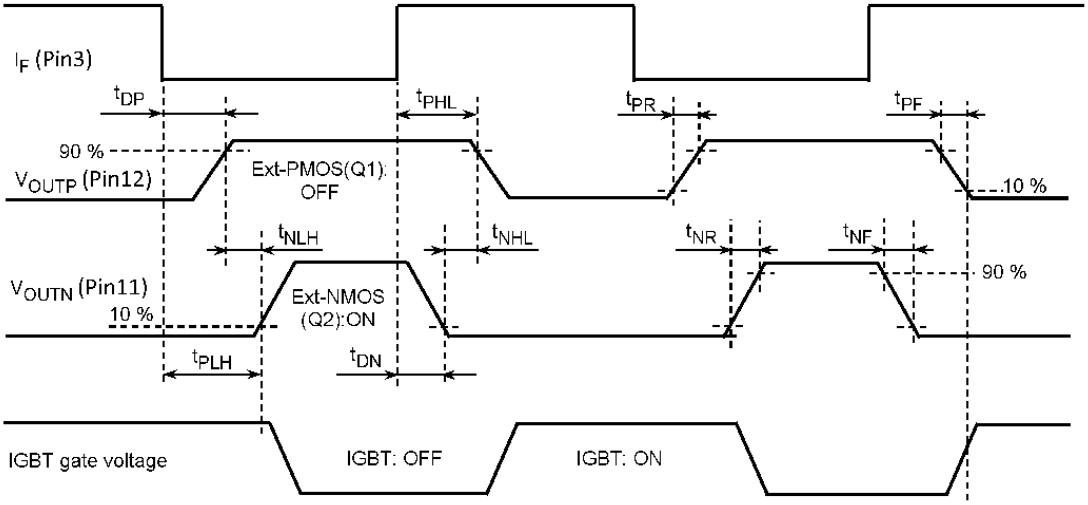


Fig. 13.2.1 Normal State

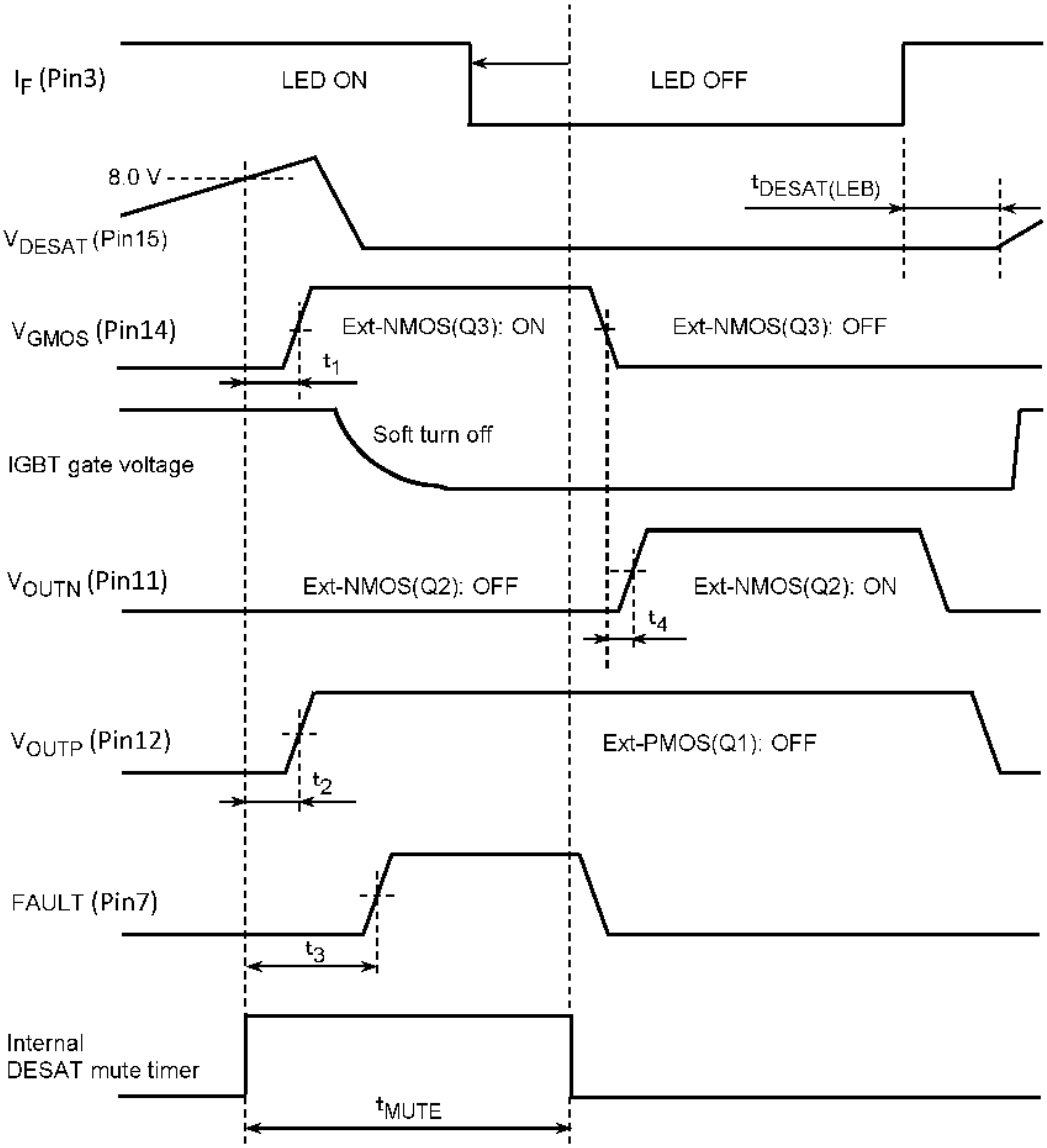


Fig. 13.2.2 DESAT Fault State (the Case that LED is Off within the t_{MUTE}: Automatic Reset)

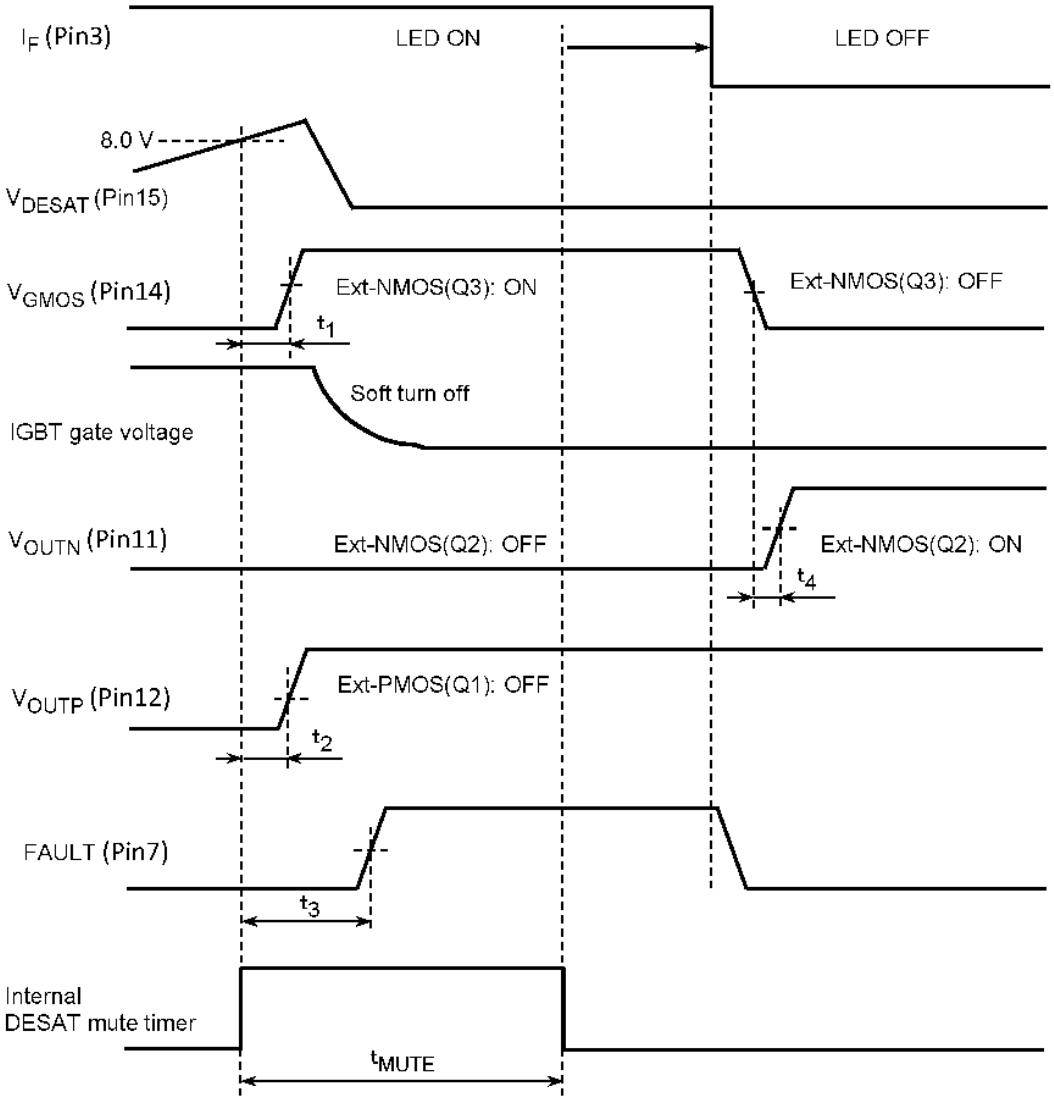


Fig. 13.2.3 DESAT Fault State (the Case that LED is Off after t_{MUTE}: Reset by LED Trigger)

13.3. Characteristics Curves (Note)

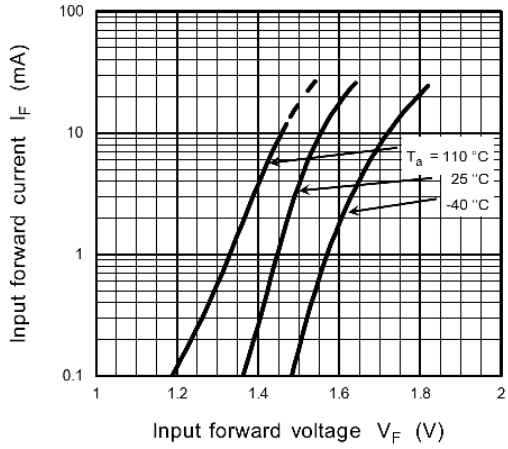


Fig. 13.3.1 I_F - V_F

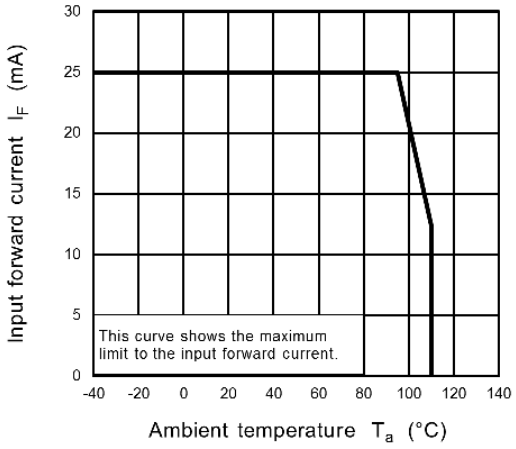


Fig. 13.3.2 I_F - T_a

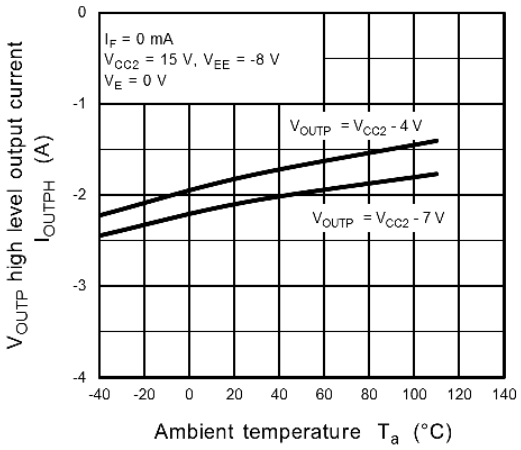


Fig. 13.3.3 I_{OUTPH} - T_a

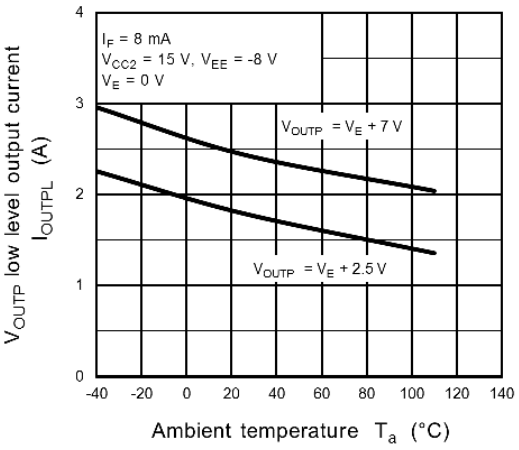


Fig. 13.3.4 I_{OUTPL} - T_a

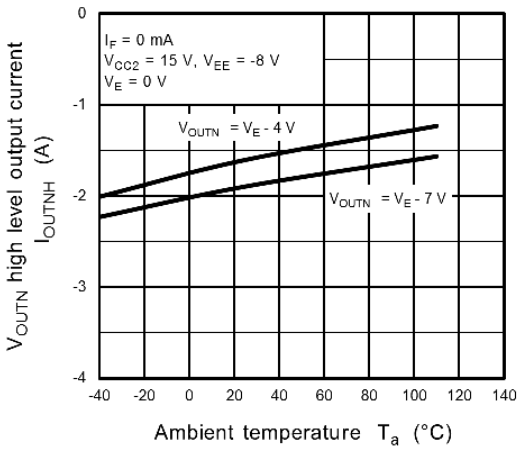


Fig. 13.3.5 I_{OUTNH} - T_a

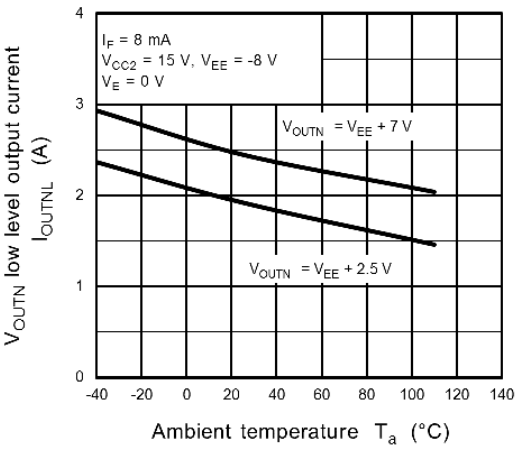


Fig. 13.3.6 I_{OUTNL} - T_a

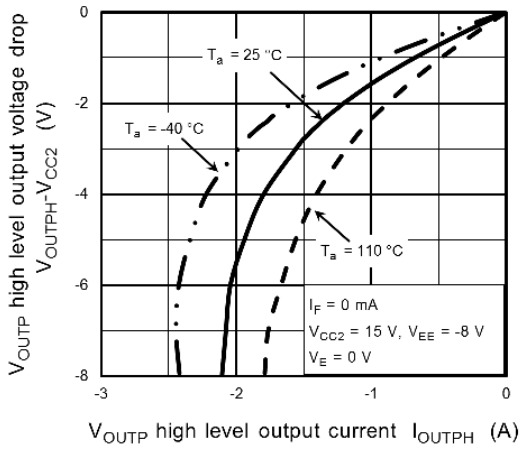


Fig. 13.3.7 (V_{OUTPH} - V_{CC2}) - I_{OUTPH}

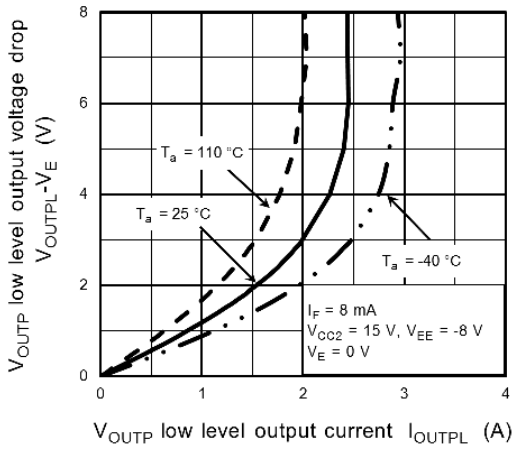


Fig. 13.3.8 (V_{OUTPL} - V_E) - I_{OUTPL}

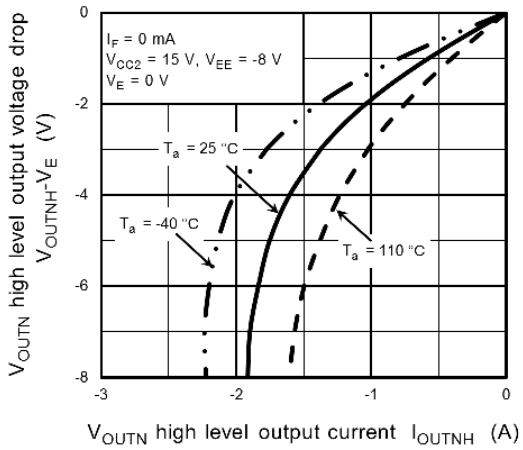


Fig. 13.3.9 (V_{OUTNH} - V_E) - I_{OUTNH}

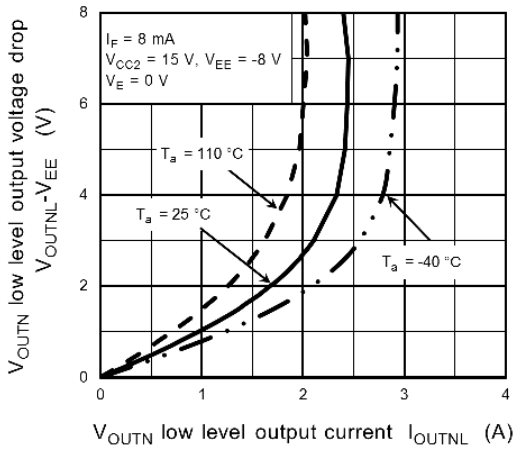


Fig. 13.3.10 (V_{OUTNL} - V_{EE}) - I_{OUTNL}

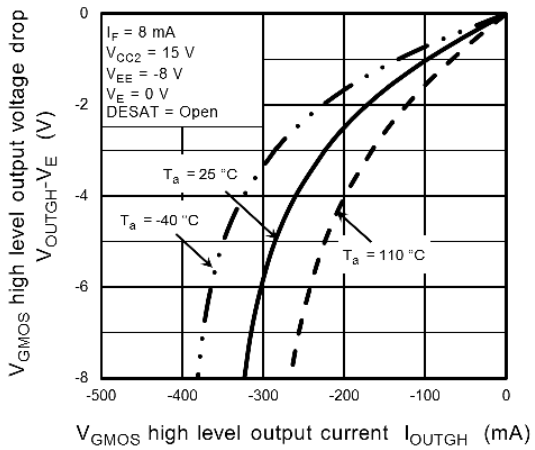


Fig. 13.3.11 (V_{OUTGH} - V_E) - I_{OUTGH}

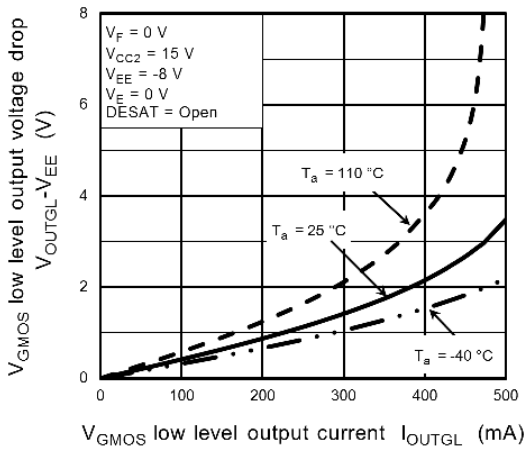


Fig. 13.3.12 (V_{OUTGL} - V_{EE}) - I_{OUTGL}

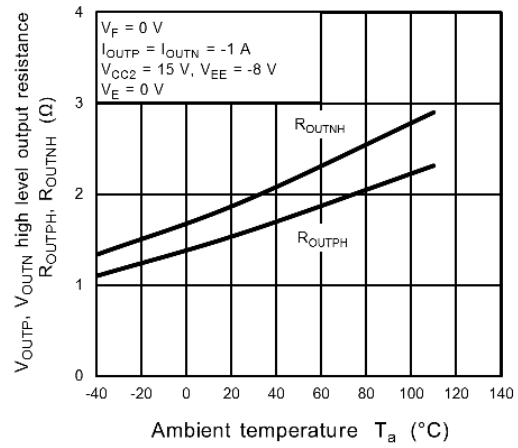


Fig. 13.3.13 R_{OUTPH}, R_{OUTNH} - T_a

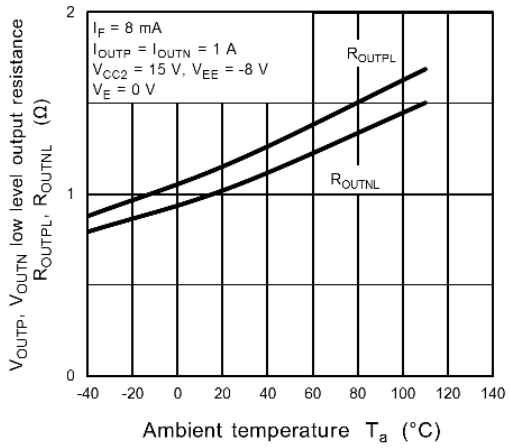


Fig. 13.3.14 R_{OUTPL}, R_{OUTNL} - T_a

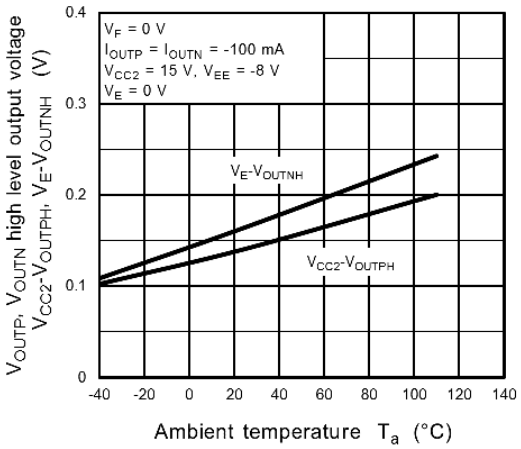


Fig. 13.3.15 V_{CC2} - V_{OUTPH}, V_E - V_{OUTNH} - T_a

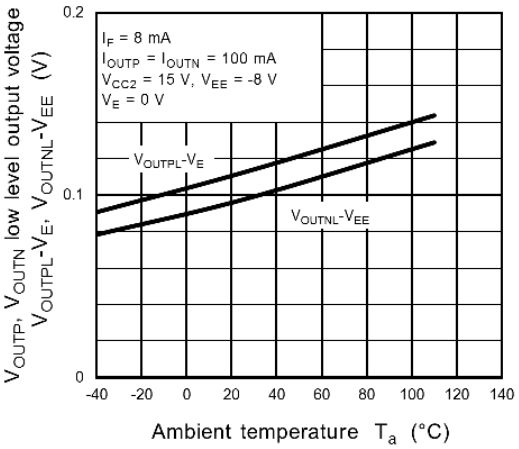


Fig. 13.3.16 V_{OUTPL} - V_E, V_{OUTNL} - V_{EE} - T_a

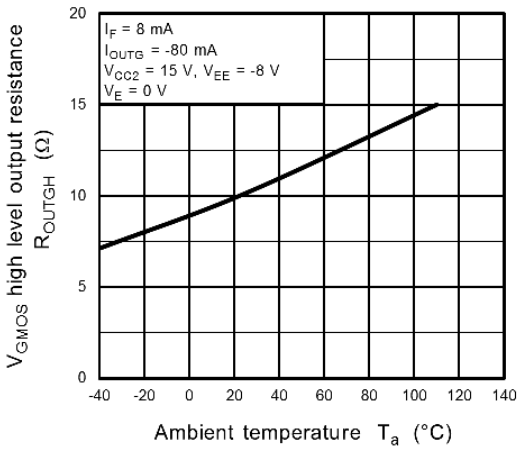


Fig. 13.3.17 R_{OUTGH} - T_a

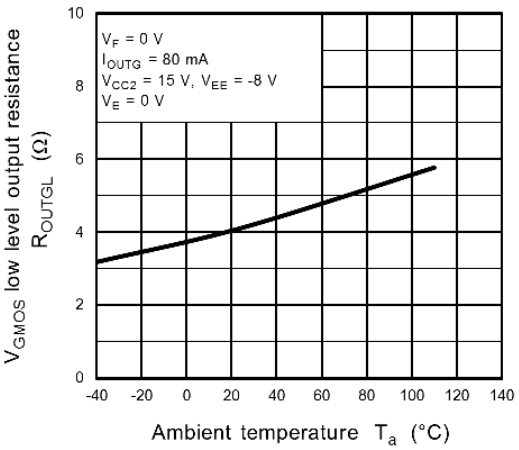


Fig. 13.3.18 R_{OUTGL} - T_a

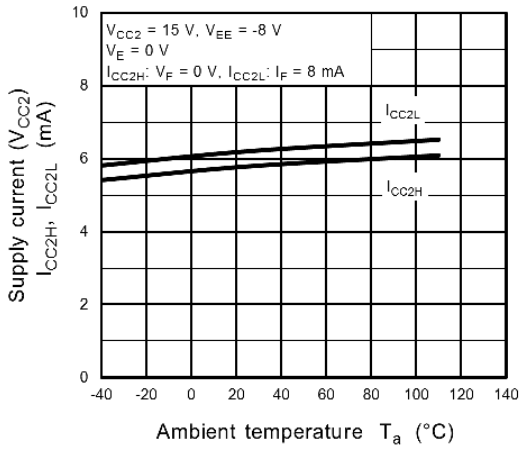


Fig. 13.3.19 I_{CC2H}, I_{CC2L} - T_a

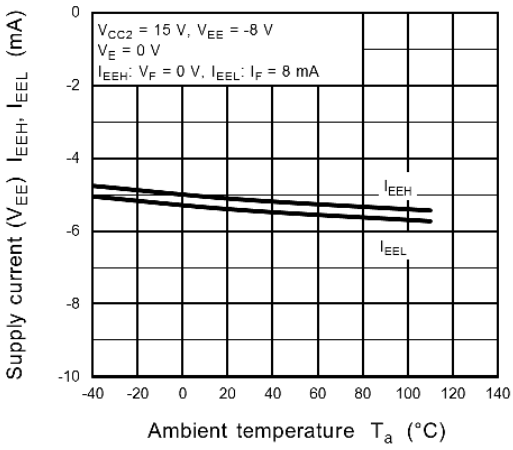


Fig. 13.3.20 I_{EEH}, I_{EEL} - T_a

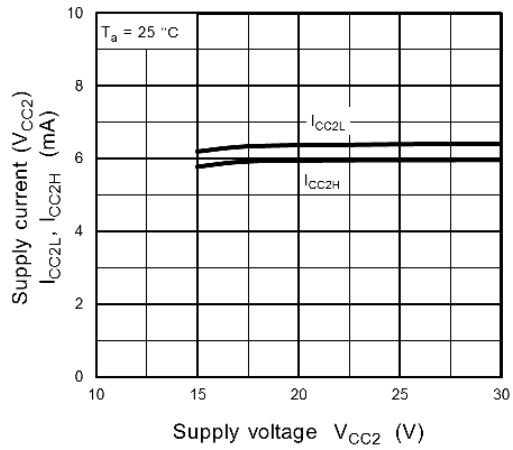


Fig. 13.3.21 I_{CC2H}, I_{CC2L} - V_{CC2}

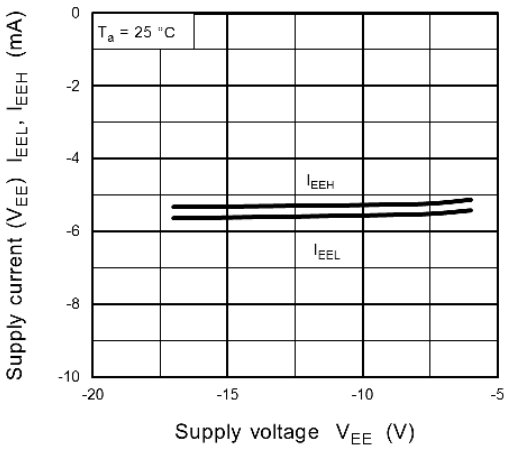


Fig. 13.3.22 I_{EEH}, I_{EEL} - V_{EE}

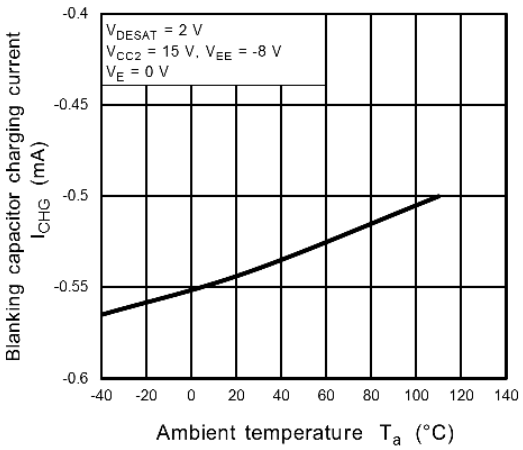


Fig. 13.3.23 I_{CHG} - T_a

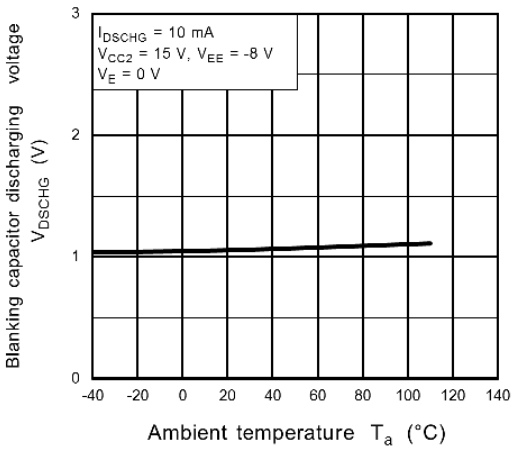


Fig. 13.3.24 V_{DSCHG} - T_a

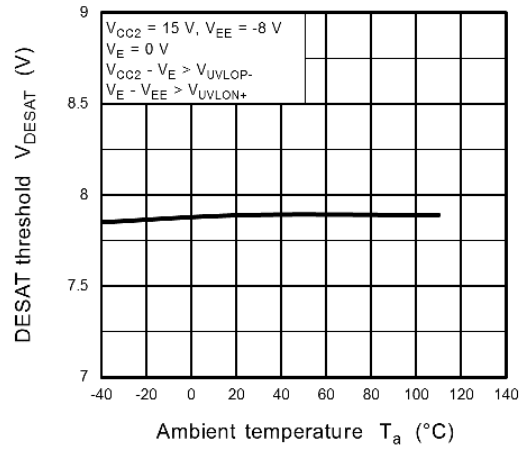


Fig. 13.3.25 V_{DESAT} - T_a

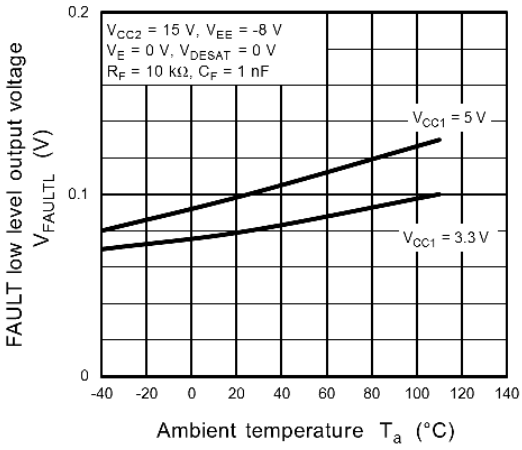


Fig. 13.3.26 V_{FAULTL} - T_a

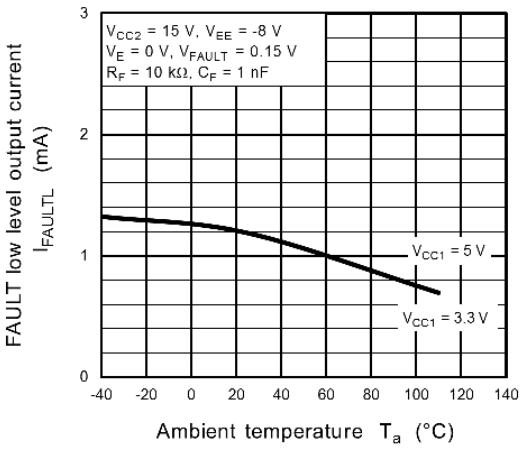


Fig. 13.3.27 I_{FAULTL} - T_a

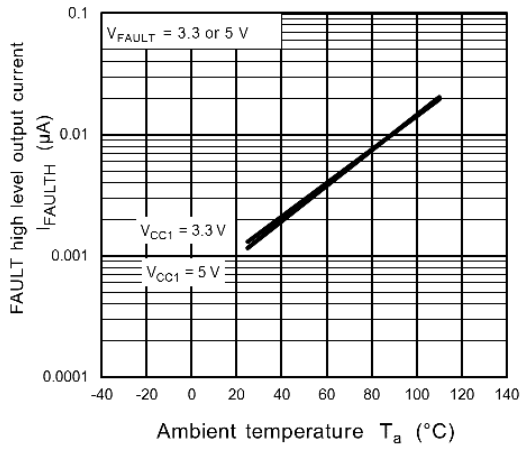


Fig. 13.3.28 I_{FAULTH} - T_a

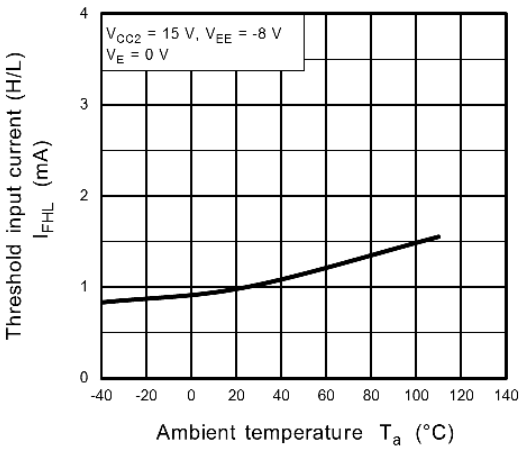


Fig. 13.3.29 I_{FHL} - T_a

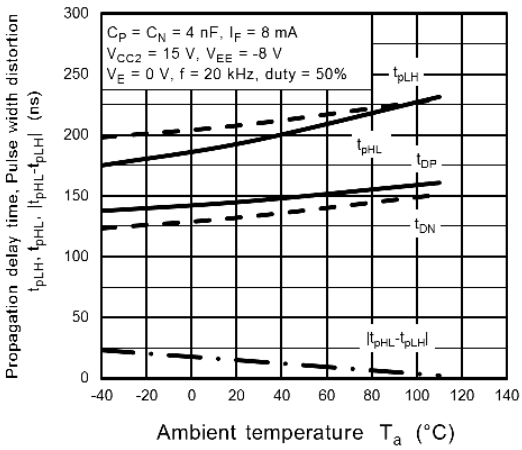


Fig. 13.3.30 t_{pLH}, t_{pHL}, $|t_{pHL} - t_{pLH}|$ - T_a

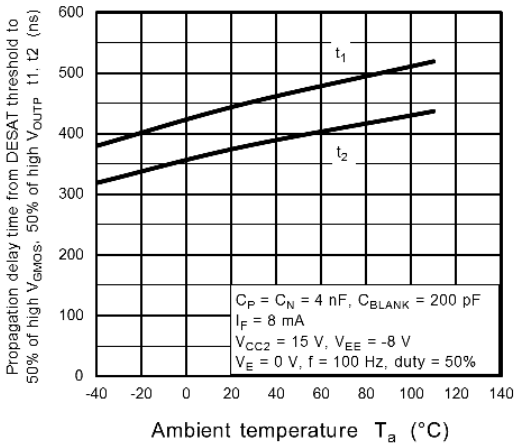


Fig. 13.3.31 t_1, t_2 - T_a

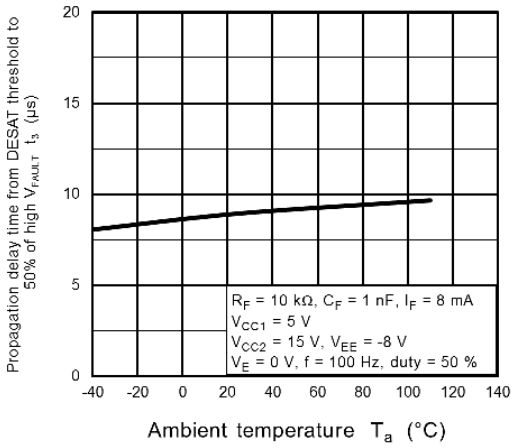


Fig. 13.3.32 t_3 - T_a

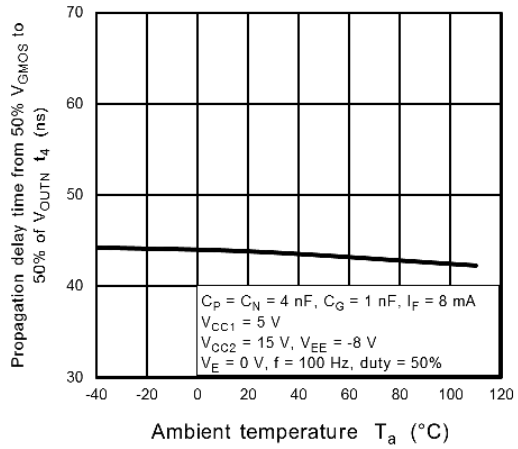


Fig. 13.3.33 t_4 - T_a

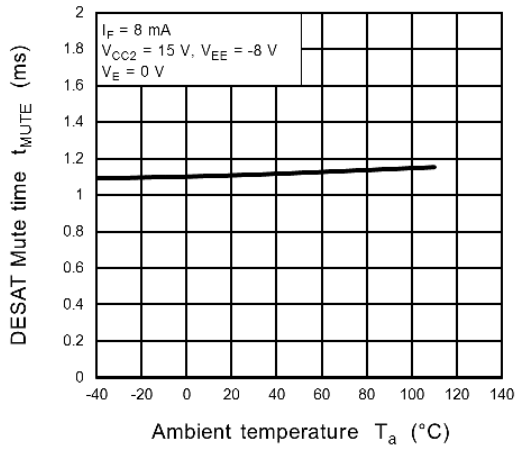


Fig. 13.3.34 t_{MUTE} - T_a

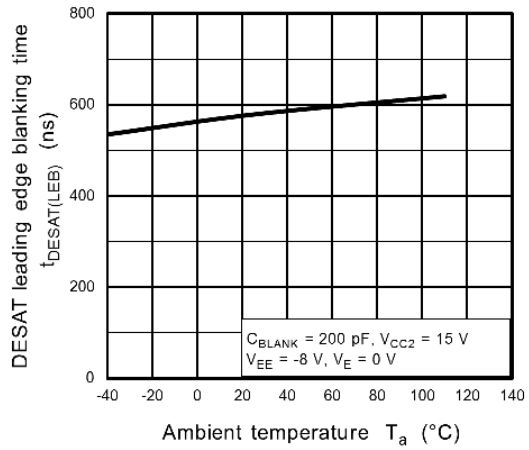


Fig. 13.3.35 $t_{DESAT(LEB)}$ - T_a

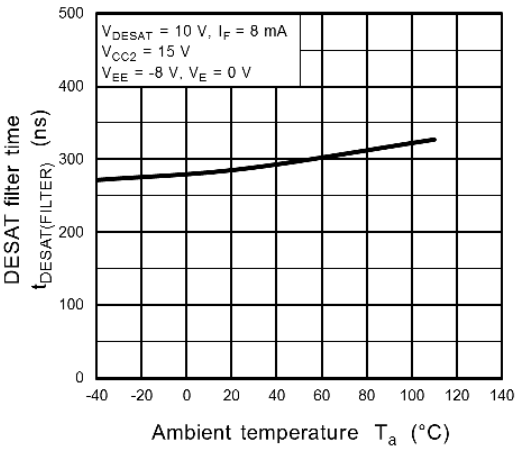


Fig. 13.3.36 $t_{DESAT(FILTER)}$ - T_a

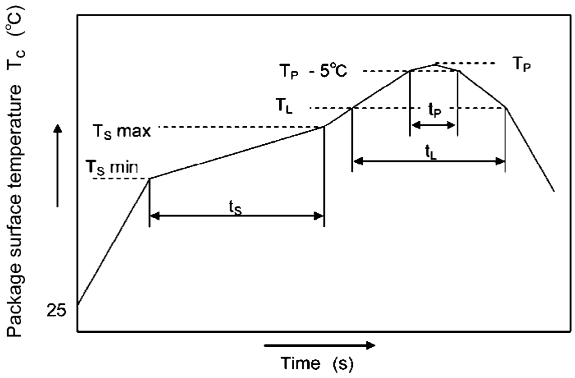
Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

14. Soldering and Storage

14.1. Precautions for Soldering

The soldering temperature should be controlled as closely as possible to the conditions shown below, irrespective of whether a soldering iron or a reflow soldering method is used.

- When using soldering reflow.
  The soldering temperature profile is based on the package surface temperature.
  (See the figure shown below, which is based on the package surface temperature.)
  Reflow soldering must be performed once or twice.
  The mounting should be completed with the interval from the first to the last mountings being 2 weeks.



	Symbol	Min	Max	Unit
Preheat temperature	T_S	150	200	°C
Preheat time	t_S	60	120	s
Ramp-up rate (T_L to T_P)			3	°C/s
Liquidus temperature	T_L	217		°C
Time above T_L	t_L	60	150	s
Peak temperature	T_P		260	°C
Time during which T_c is between (T_P – 5) and T_P	t_P		30	s
Ramp-down rate (T_P to T_L)			6	°C/s

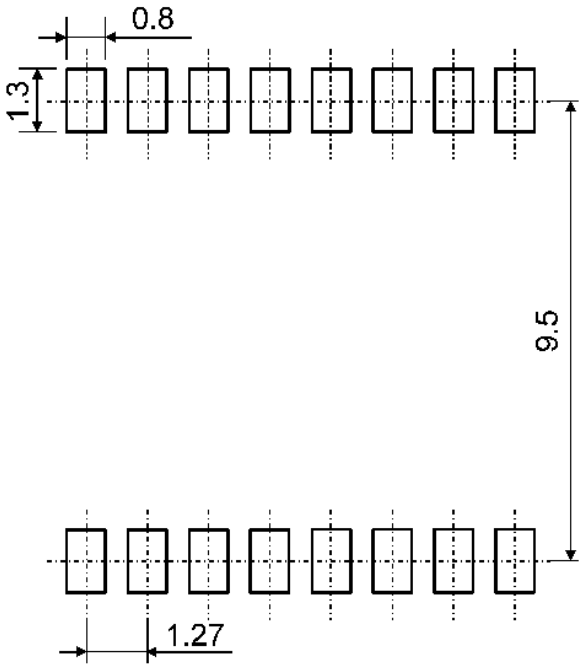
An Example of a Temperature Profile When Lead(Pb)-Free Solder Is Used

- When using soldering flow
  Preheat the device at a temperature of 150 °C (package surface temperature) for 60 to 120 seconds.
  Mounting condition of 260 °C within 10 seconds is recommended.
  Flow soldering must be performed once.
- When using soldering Iron
  Complete soldering within 10 seconds for lead temperature not exceeding 260 °C or within 3 seconds not exceeding 350 °C
  Heating by soldering iron must be done only once per lead.

14.2. Precautions for General Storage

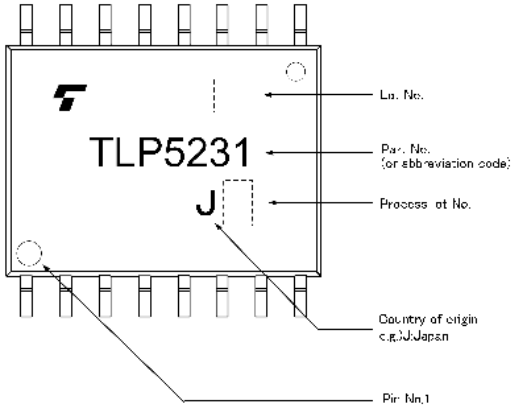
- Avoid storage locations where devices may be exposed to moisture or direct sunlight.
- Follow the precautions printed on the packing label of the device for transportation and storage.
- Keep the storage location temperature and humidity within a range of 5 °C to 35 °C and 45 % to 75 %, respectively.
- Do not store the products in locations with poisonous gases (especially corrosive gases) or in dusty conditions.
- Store the products in locations with minimal temperature fluctuations. Rapid temperature changes during storage can cause condensation, resulting in lead oxidation or corrosion, which will deteriorate the solderability of the leads.
- When restoring devices after removal from their packing, use anti-static containers.
- Do not allow loads to be applied directly to devices while they are in storage.
- If devices have been stored for more than two years under normal storage conditions, it is recommended that you check the leads for ease of soldering prior to use.

15. Land Pattern Dimensions (for reference only)



Unit: mm

16. Marking



17. EN 60747-5-5 Option (D4) Specification

- Part number: TLP5231 **(Note 1)**
- The following part naming conventions are used for the devices that have been qualified according to option (D4) of EN 60747.

  Example: TLP5231(D4-TP,E

  D4: EN 60747 option
  TP: Tape type
  E: [[G]]/RoHS COMPATIBLE **(Note 2)**

Note 1: Use TOSHIBA standard type number for safety standard application.
e.g., TLP5231(D4-TP,E → TLP5231

Note 2: Please contact your Toshiba sales representative for details on environmental information such as the product's RoHS compatibility.
RoHS is the Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

Description	Symbol	Rating	Unit
Application classification for rated mains voltage ≤ 600 Vrms for rated mains voltage ≤ 1000 Vrms		 I-IV I-III	—
Climatic classification		40 / 110 / 21	—
Pollution degree		2	—
Maximum operating insulation voltage	V_{IORM}	1230	Vpeak
Input to output test voltage, Method A V_{pr} = 1.6 × V_{IORM}, type and sample test t_p = 10 s, partial discharge < 5 pC	V_{pr}	1970	Vpeak
Input to output test voltage, Method B V_{pr} = 1.875 × V_{IORM}, 100 % production test t_p = 1 s, partial discharge < 5 pC	V_{pr}	2310	Vpeak
Highest permissible overvoltage (transient overvoltage, t_{pr} = 60 s)	V_{TR}	8000	Vpeak
Safety limiting values (max. permissible ratings in case of fault, also refer to thermal derating curve) current (input current I_F, P_{so} = 0) power (output or total power dissipation) temperature	 I_{si} P_{so} T_s	 400 1200 175	 mA mW °C
Insulation resistance V_{IO} = 500 V, T_a = 25 °C V_{IO} = 500 V, T_a = 100 °C V_{IO} = 500 V, T_a = T_s	R_{si}	≥ 10^{12} ≥ 10^{11} ≥ 10^{9}	Ω

Fig. 17.1 EN 60747 Insulation Characteristics

Minimum creepage distance	Cr	8.0 mm
Minimum clearance	Cl	8.0 mm
Minimum insulation thickness	ti	0.4 mm
Comparative tracking index	CTI	500

Fig. 17.2 Insulation Related Specifications (Note)

Note: This photocoupler is suitable for **safe electrical isolation** only within the safety limit data. Maintenance of the safety data shall be ensured by means of protective circuits.

Fig. 17.3 Marking on Packing for EN 60747

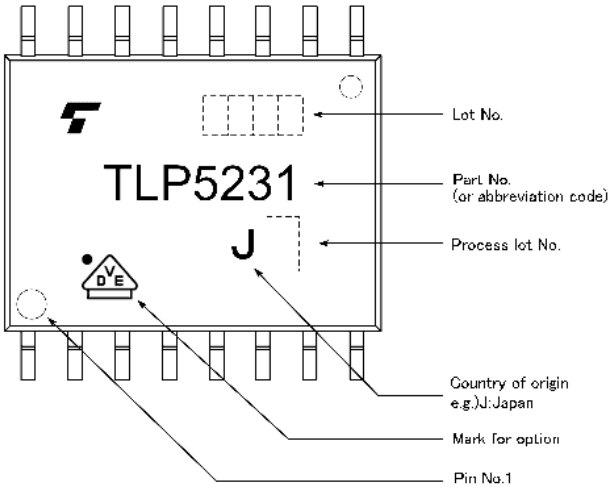


Fig. 17.4 Marking Example (Note)

Note: The above marking is applied to the photocouplers that have been qualified according to option (D4) of EN 60747.

Figure 1 Partial discharge measurement procedure according to EN 60747
Destructive test for qualification and sampling tests.

Method A

(for type and sampling tests, destructive tests)

t1, t2	= 1 to 10 s
t3, t4	= 1 s
tp (Measuring time for partial discharge)	= 10 s
tb	= 12 s
tini	= 60 s

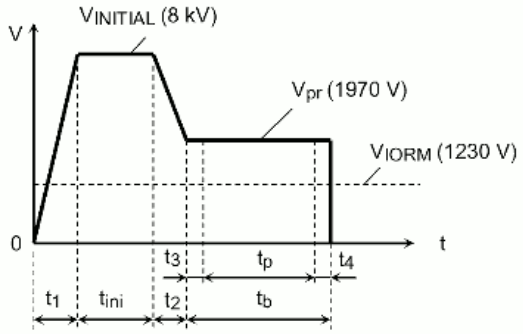


Figure 2 Partial discharge measurement procedure according to EN 60747
Non-destructive test for 100 % inspection.

Method B

(for sample test, non-destructive test)

t3, t4	= 0.1 s
tp (Measuring time for partial discharge)	= 1 s
tb	= 1.2 s

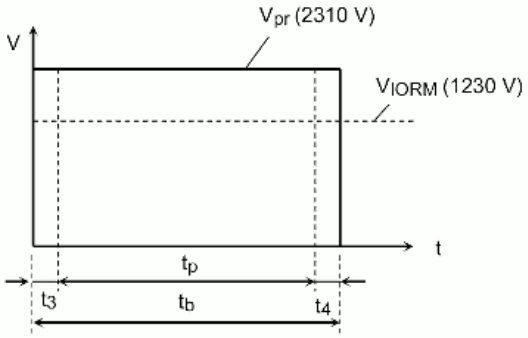


Figure 3 Dependency of maximum safety ratings on ambient temperature

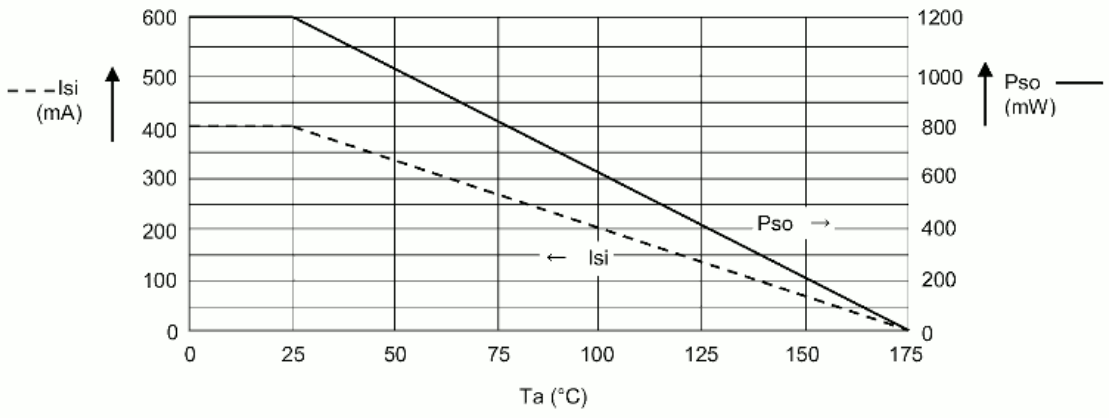


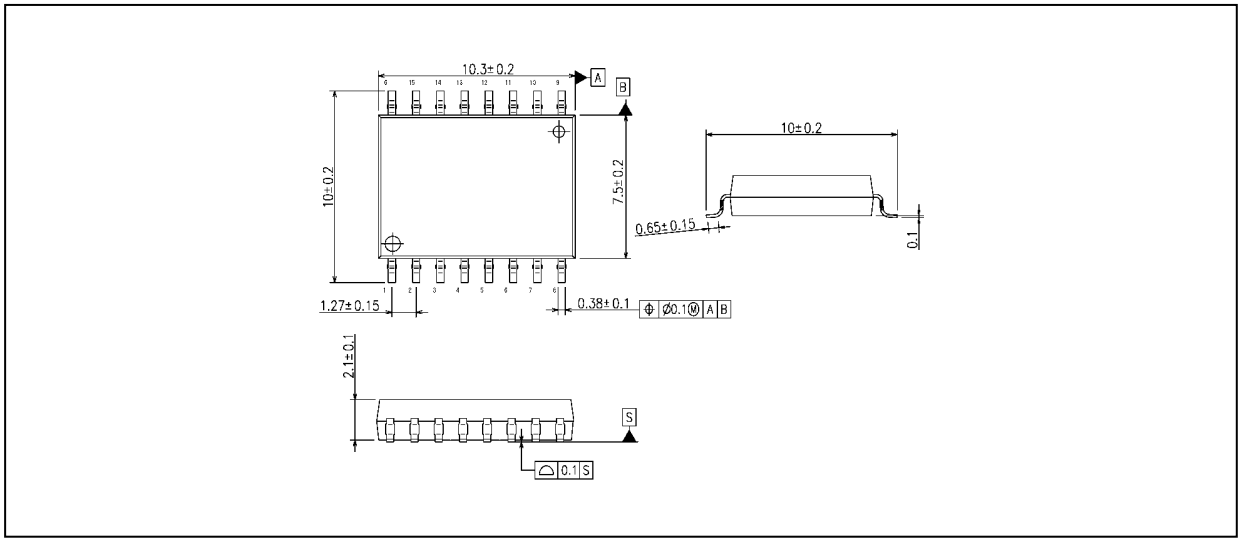
Fig. 17.5 Measurement Procedure

18. Ordering Information (Example of Item Name)

Item Name	VDE Option	Packing (MOQ)
TLP5231(E		Magazine (50 pcs)
TLP5231(TP,E		Tape and reel (1500 pcs)
TLP5231(D4,E	EN 60747-5-5	Magazine (50 pcs)
TLP5231(D4-TP,E	EN 60747-5-5	Tape and reel (1500 pcs)

Package Dimensions

Unit: mm



Weight: 0.364 g (typ.)

Package Name(s)
TOSHIBA: 11-10M1

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