Photocouplers Optically Isolated Delta-Sigma Modulator

TLP7830

1. Applications

- Motor phase and rail current sensing
- Power inverter current and voltage sensing

2. General

The TLP7830 is a 1-bit, second-order delta-sigma (Δ-Σ) modulator converts an analog input signal into a high-speed data stream with galvanic isolation based on optical coupling technology.

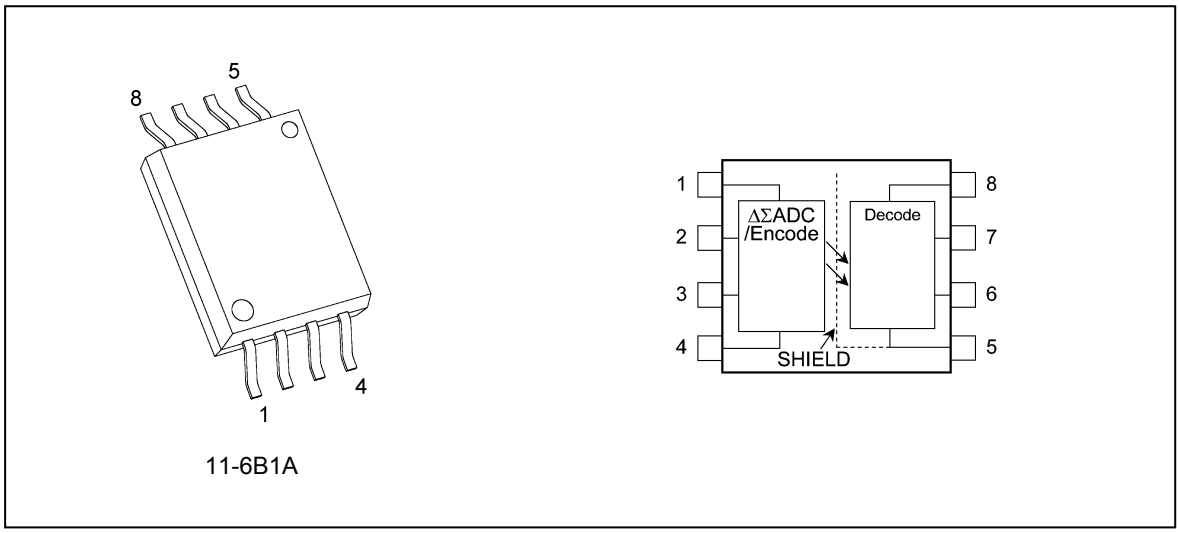
3. Features

(1) Output clock frequency: 10 MHz (typ.)
(2) 16 bits resolution no missing codes [ENOB: 12 bits (typ.)]
(3) Integral non-linearity: 4 LSB (typ.)
(4) Input offset voltage: 0.6 mV (typ.)
(5) Operating temperature range: -40 to 105 ℃
(6) Common-mode transient immunity: 15 kV/μs (min)
(7) 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
2016-01

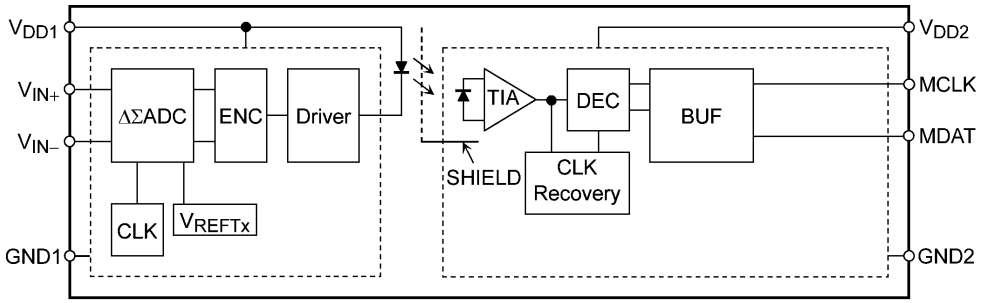
4. Packaging and Pin Assignment



4.1. Pin Assignment

Pin No.	Symbol	Description
1	V_{DD1}	Input side supply voltage
2	V_{IN+}	Positive input
3	V_{IN-}	Negative input
4	GND1	Input side ground
5	GND2	Output side ground
6	MDAT	Modulator data output
7	MCLK	Modulator clock output
8	V_{DD2}	Output side supply voltage

5. Internal Circuit (Note)



Note: A 0.1-μF bypass capacitor must be connected between 1 and 4 pins and between 5 and 8 pins.

6. Principle of Operation

6.1. Mechanical Parameters

Characteristics	Size	Unit
Height	2.3 (max)	mm
Creepage distances	8.0 (min)	
Clearance	8.0 (min)	
Internal isolation thickness	0.4 (min)	

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

Characteristics		Symbol	Note	Rating	Unit
Supply voltages		V_{DD1}, V_{DD2}		-0.5 to 6	V
Steady-state input voltages		V_{IN+}, V_{IN-}		-0.5 to V_{DD1} + 0.5	V
Two-second transient input voltages		V_{IN+}, V_{IN-}		-6 to V_{DD1} + 0.5	V
Input power dissipation		P_D		72	mW
Input power dissipation derating	($T_a \geq$ 110.6°C)	$\Delta P_D/\Delta T_a$		-5.0	mW/°C
Digital output voltage		MCLK, MDAT		-0.5 to 6	V
Output power dissipation		P_O		48	mW
Output power dissipation derating	($T_a \geq$ 115.4°C)	$\Delta P_O/\Delta T_a$		-5.0	mW/°C
Operating temperature		T_{opr}		-40 to 105	°C
Storage temperature		T_{stg}		-55 to 125	°C
Lead soldering temperature	(10 s)	T_{sol}	(Note 1)	260	°C
Isolation voltage	(AC, 60 s, R.H. ≤ 60 %)	BV_S	(Note 2)	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: Ceramic capacitors (0.1 μF) should be connected between 1 and 4 pins and between 5 and 8 pins to stabilize the operation. Otherwise, this photocoupler may not switch properly. The bypass capacitors should be placed as close as possible to each pin.

Note 1: ≥ 2 mm below seating plane.

Note 2: This device is considered as a two-terminal device: Pins 1, 2, 3 and 4 are shorted together, and pins 5, 6, 7 and 8 are shorted together.

8. Recommended Operating Conditions (Note)

Characteristics	Symbol	Note	Min	Typ.	Max	Unit
Input side supply voltage	V_{DD1}		4.5	5	5.5	V
Output side supply voltage	V_{DD2}		3	—	5.5	V
Analog input voltage	V_{IN+}, V_{IN-}	(Note 1), (Note 2)	-200	—	200	mV
Ambient temperature	T_a		-40	—	105	°C

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 1: FSR = ±320 mV

Note 2: When either V_{IN+} or V_{IN-} or both are equal to or greater than V_{DD1} - 2 V (e.g., if V_{DD1} = 5 V, when V_{IN+} and/or V_{IN-} are equal to or greater than 5 V - 2 V = 3 V), isolation amplifiers go into one of the test modes. Do not raise either V_{IN+} or V_{IN-} above this voltage to keep the device in functional mode.

9. Electrical Characteristics

9.1. DC Characteristics (Note) (Unless otherwise specified, T_a = -40 to 105 °C, V_{DD1} = 4.5 to 5.5 V, V_{DD2} = 3 to 5.5 V, V_{IN+} = -200 to 200 mV, V_{IN-} = 0 V)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Integral non-linearity	INL	T_a = -40 to 85 °C	-15	4	15	LSB
		T_a = 105 °C	-25	4	25	
Differential non-linearity	DNL		-0.9	0.5	0.9	LSB
Input offset voltage	V_{OS}		-1.0	0.6	2.0	mV
Input offset voltage drift vs ambient temperature	$\lvert dV_{OS}/dT_a \rvert$		—	1.2	3	μV/°C
Input offset voltage drift vs input side supply voltage	$\lvert dV_{OS}/dV_{DD1} \rvert$		—	150	—	μV/V
Internal reference voltage	V_{REF}		—	320	—	mV
Gain error	G_E	T_a = 25 °C	-1	0.1	1	%
		T_a = -40 to 105 °C	-2	0.1	2	
Input common-mode rejection ratio	$CMRR_{IN}$		—	74	—	dB
Signal-to-noise ratio	SNR	V_{IN+} = 400 mV_{p-p}, 1 kHz sine wave	68	80	—	dB
Signal-to-(noise + distortion) ratio	SNDR		65	75	—	dB
Effective number of bits	ENOB		—	12	—	bits
Total harmonic distortion	THD		—	-78	—	dB
Input side supply current (V_{DD1})	I_{DD1}	V_{IN+} = 0 V	—	8.5	12	mA
Output side supply current (V_{DD2})	I_{DD2}	V_{IN+} = 0 V, V_{DD2} = 3.3 V	—	4.6	7	mA
		V_{IN+} = 0 V, V_{DD2} = 5 V	—	4.9	8	
Low-level output voltage	V_{OL}	I_{OUT} = 200 μA	—	0.03	0.05	V
High-level output voltage	V_{OH}	I_{OUT} = -200 μA, V_{DD2} = 3.3 V	3.1	3.2	—	V
		I_{OUT} = -200 μA, V_{DD2} = 5 V	4.8	4.9	—	
Equivalent input resistance	R_{IN}		—	80	—	kΩ

Note: Tested with a $Sinc^3$ filter with a decimation ratio of 256 (with the decimation filter output configured to 16 bits).

Note: All typical values are at V_{DD1} = 5 V, V_{DD2} = 5 V, T_a = 25 °C, unless otherwise noted.

10. AC Characteristics (Note) (Unless otherwise specified, T_a = -40 to 105 °C, V_{DD1} = 4.5 to 5.5 V, V_{DD2} = 3 to 5.5 V)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Output clock frequency	f_{CLK}		8.5	10	11.5	MHz
Access time after MCLK rising edge	t_a	C_L = 15 pF	—	33	45	ns
Hold time after MCLK rising edge	t_h		10	24	—	ns
Common-mode transient immunity	CMTI	V_{CM} = 1 kV, T_a = 25 °C	15	20	—	kV/μs

Note: All typical values are at T_a = 25 °C.
C_L is approximately 15 pF which includes probe and stray wiring capacitance.

11. 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, 2, 3 and 4 are shorted together, and pins 5, 6, 7 and 8 are shorted together.

12. Characteristics Curves (Note)

V_{IN-} = 0 V. Tested with a Sinc³ filter with a decimation ratio of 256 (with the decimation filter output configured to 16 bits)

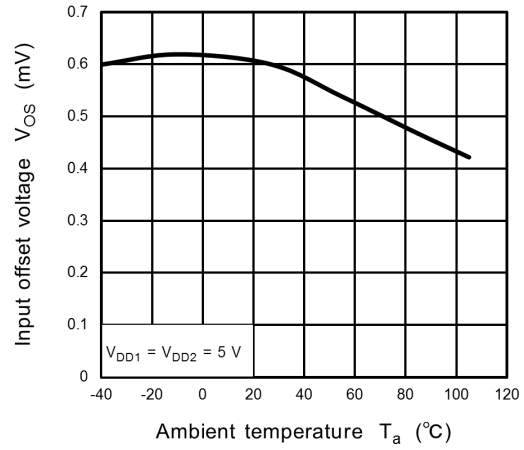


Fig. 12.1 V_{OS} - T_a

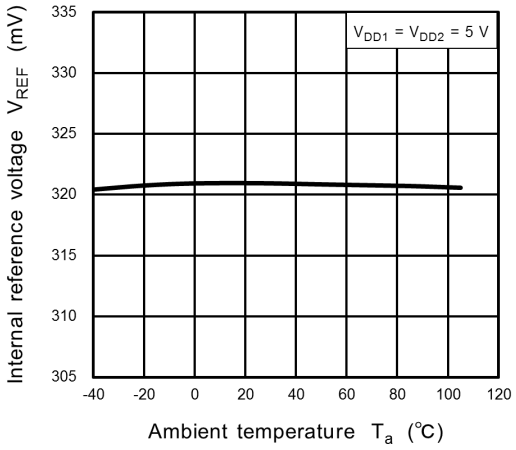


Fig. 12.2 V_{REF} - T_a

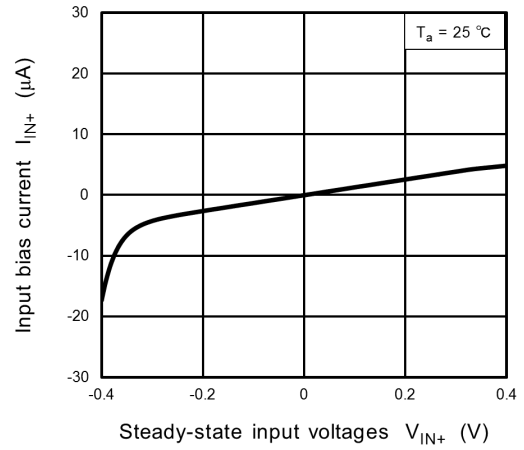


Fig. 12.3 V_{IN+} - I_{IN+}

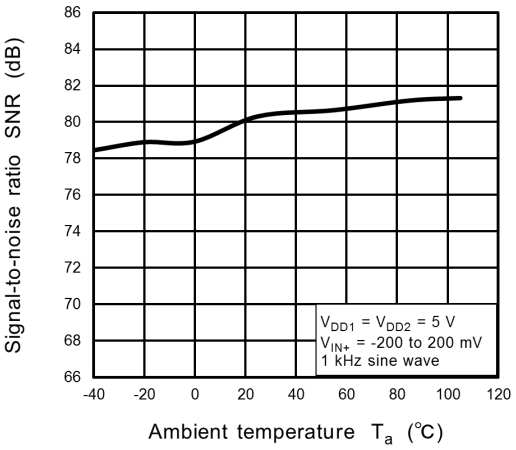


Fig. 12.4 SNR - T_a

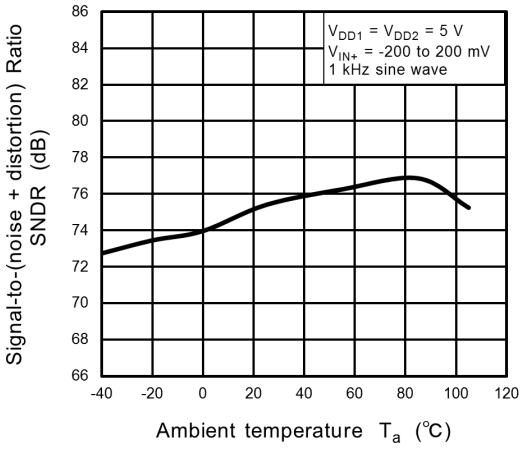


Fig. 12.5 SNDR - T_a

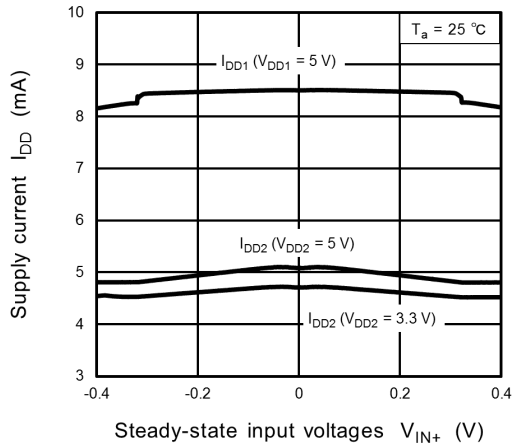


Fig. 12.6 I_{DD} - V_{IN+}

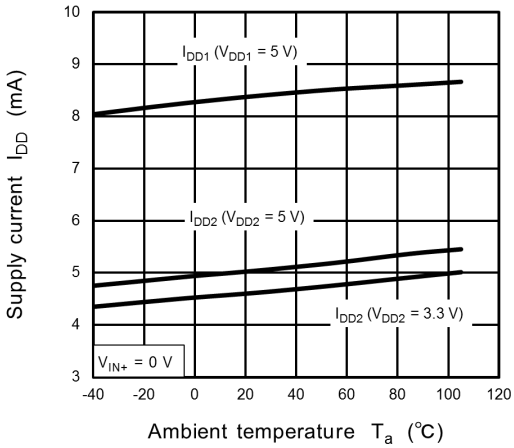


Fig. 12.7 I_{DD} - T_a

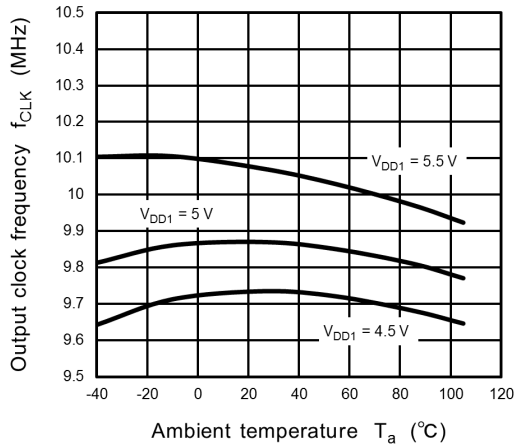


Fig. 12.8 f_{CLK} - T_a

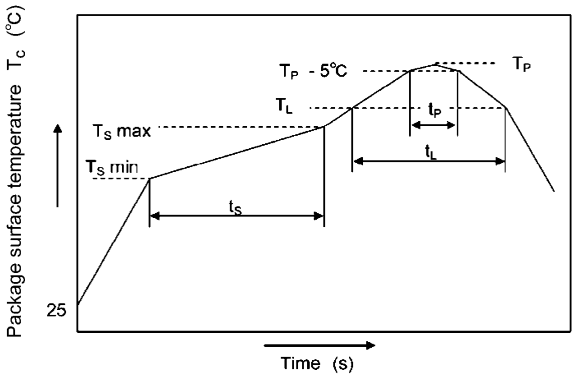
Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

13. Soldering and Storage

13.1. 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

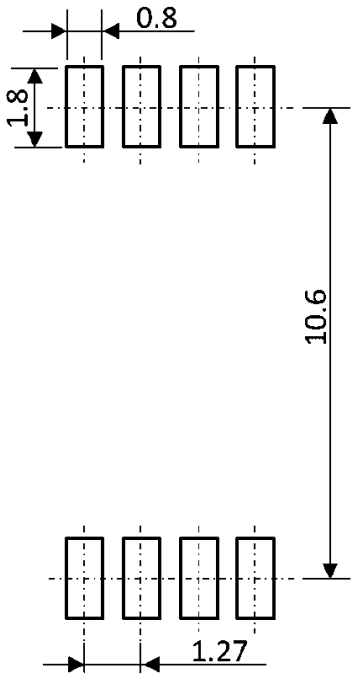
An Example of a Temperature Profile When Lead(Pb)-Free Solder Is Used

- 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.

13.2. Precautions for General Storage

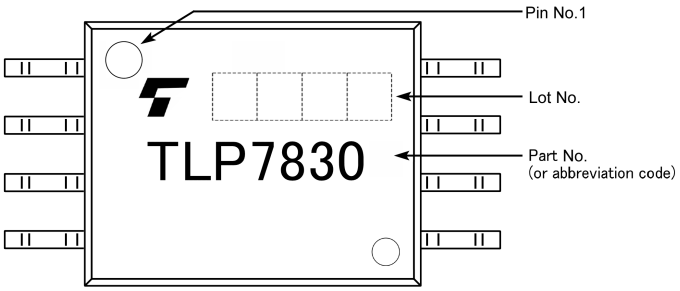
- Avoid storage locations where devices may be exposed to moisture or direct sunlight.
- Follow the precautions printed on the packing label of the device for transportation and storage.
- Keep the storage location temperature and humidity within a range of 5 °C to 35 °C and 45 % to 75 %, respectively.
- 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.

14. Land Pattern Dimensions (for reference only)



Unit: mm

15. Marking



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

- Part number: TLP7830 **(Note 1)**
- The following part naming conventions are used for the devices that have been qualified according to option (D4) of EN 60747.

Example: TLP7830(D4-TP4,E

D4: EN 60747 option
TP4: Tape type
E: [[G]]/RoHS COMPATIBLE **(Note 2)**

Note 1: Use TOSHIBA standard type number for safety standard application.
e.g., TLP7830(D4-TP4,E → TLP7830

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 / 105 / 21	—
Pollution degree		2	—
Maximum operating insulation voltage	V_{IORM}	1414	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}	2262	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}	2652	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	 300 700 150	 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}	$\geq 10^{12}$ $\geq 10^{11}$ $\geq 10^{9}$	Ω

Fig. 16.1 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. 16.2 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. 16.3 Marking on Packing

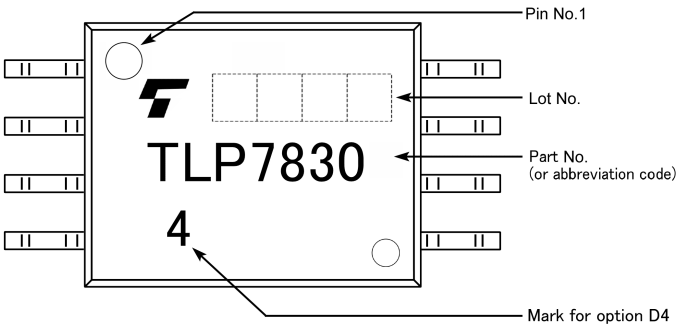


Fig. 16.4 Marking Example (Note)

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)

t_1, t_2	= 1 to 10 s
t_3, t_4	= 1 s
t_p (Measuring time for partial discharge)	= 10 s
t_b	= 12 s
t_{ini}	= 60 s

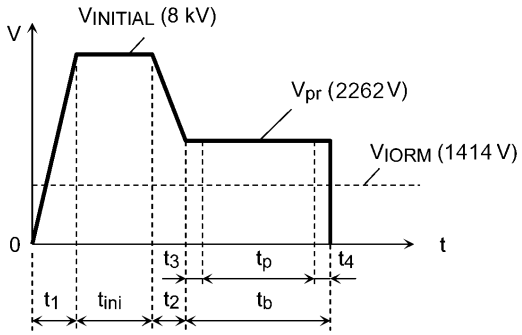


Figure 2 Partial discharge measurement procedure according to EN 60747
Non-destructive test for 100 % inspection.

Method B

(for sample test,non-destructive test)

t_3, t_4	= 0.1 s
t_p (Measuring time for partial discharge)	= 1 s
t_b	= 1.2 s

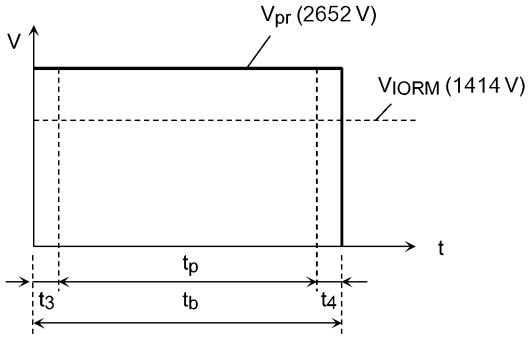


Figure 3 Dependency of maximum safety ratings on ambient temperature

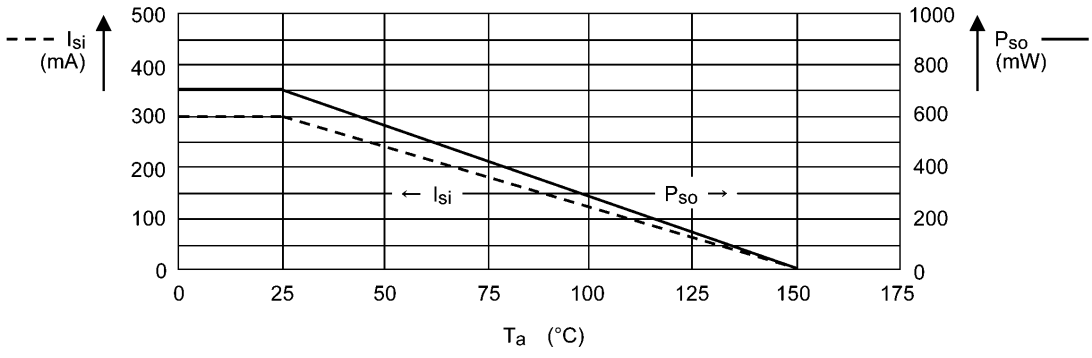


Fig. 16.5 Measurement Procedure

17. Ordering Information

When placing an order, please specify the part number, tape type and quantity as shown in the following example.

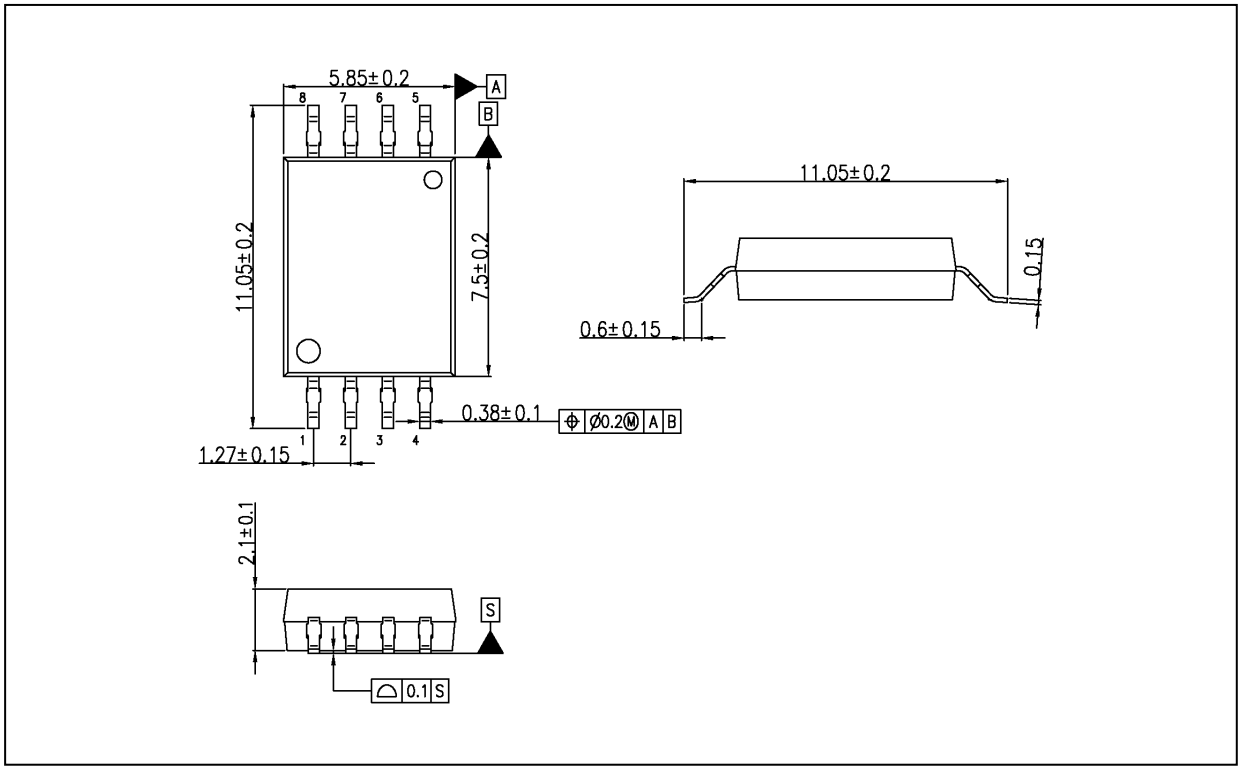
Example) TLP7830(TP4,E 1500 pcs

Part number: TLP7830
Tape type: TP4
[[G]]/RoHS COMPATIBLE: E **(Note 1)**
Quantity (must be a multiple of 1500): 1500 pcs

Note 1: 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.

Package Dimensions

Unit: mm



Weight: 0.205 g (typ.)

Package Name(s)
TOSHIBA: 11-6B1A

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