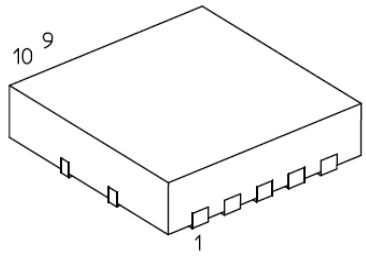
Toshiba Intelligent Power Device Silicon Monolithic MOS Integrated Circuit

TPD1058FA

Low-Side Switch for Solenoid, Motor and Lamp Drive

1. Description

The TPD1058FA is a monolithic power IC for low-side switches.
The IC has a MOSFET (D-MOS) output which can be directly driven from a CMOS or TTL logic circuit (e.g., an MPU). The IC is equipped with intelligent self-protective functions and diagnostic functions.



P-WSON10-0303-0.50-001

Weight: 0.02 g (typ.)

2. Applications

Solenoid drive, motor drive and lamp drive.

3. Features

- A monolithic power IC with a new structure combining a control block and a power MOSFET (DMOS) on single chip.
- AEC-Q100 qualified.
- Can directly drive a power load from CMOS or TTL logic.
- Built-in protection against overvoltage (active clamp), over temperature (thermal shutdown), and over current.
- Incorporates a diagnosis function that allows diagnosis output to be read externally at load short-circuiting, opening, or over temperature.
- Low Drain-Source ON-resistance:
  $R_{DS\ (ON)}$ = 0.1 Ω (max) (@V_{DD} = 5 V, V_{STBY} = 5 V, V_{IN} = 5 V, I_O = 2 A, T_{ch} = 25 °C)
- Low Standby Current:
  I_{DD} = 10 μA (max) (@V_{IN} = 0 V, V_{STBY} = 0 V, V_{DD} = 5 V, T_{ch} = -40 to 125 °C)
- WSON10 package with embossed-tape packing.

Note: Due to its MOS structure, this product is sensitive to static electricity.

Start of commercial production
2015-04

4. Block Diagram / Application Circuit

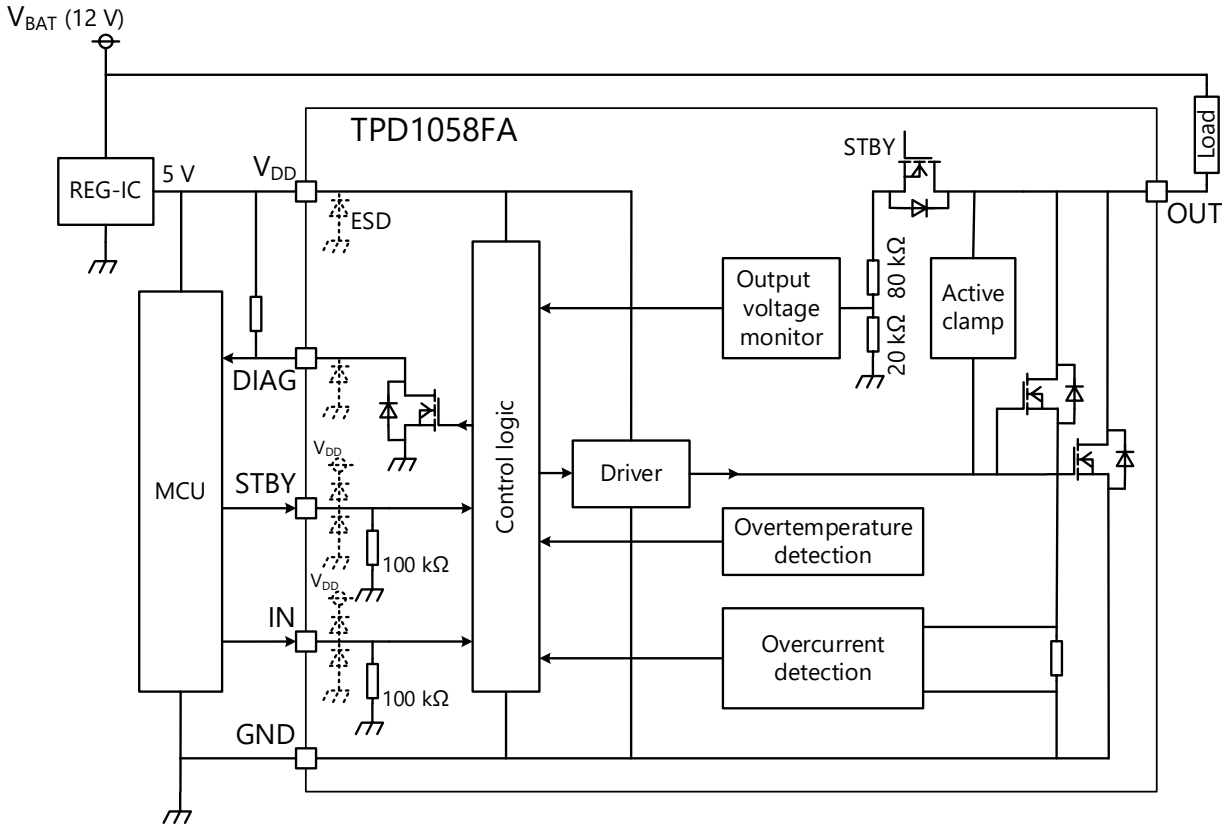


Figure 4.1 Block Diagram

Note: The value in block diagram is a standard value in Tch = 25°C

5. Pin Assignments

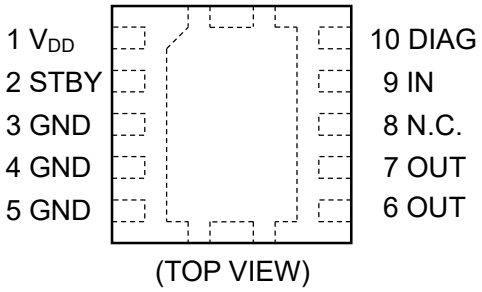


Figure 5.1 Pin Assignments

6. Pin Description

Table 6.1 Pin Description

Pin No.	Symbol	I/O	Pin Description
1	V_{DD}	—	Power supply pin.
2	STBY	IN	Standby pin. This pin has an internal pull-down resistor (100 kΩ (typ.)). In the case of open state, it becomes standby mode same as $V_{STBY} = V_{IL}$. $V_{STBY} = V_{IL}$: $I_{DD} \leq 10$ μA (Standby mode) $V_{STBY} = V_{IH}$: Active control
3, 4, 5	GND	—	Ground pin. Please connect exposed pad to electrical open or GND.
6, 7	OUT	OUT	Output pin. When a load short-circuit causes an overcurrent 6 A (min) to flow into a device, output current is limited in order to protect the IC.
8	N.C	—	No-Connect pin (not connected to the chip).
9	IN	IN	Input pin. The IN pin has an internal pull-down resistor (100 kΩ (typ.)). Even if the IN pin is open, the output will not accidentally turn on.
10	DIAG	OUT	Self-diagnosis output pin. N-channel open drain.

7. Functional Description

7.1. Timing chart

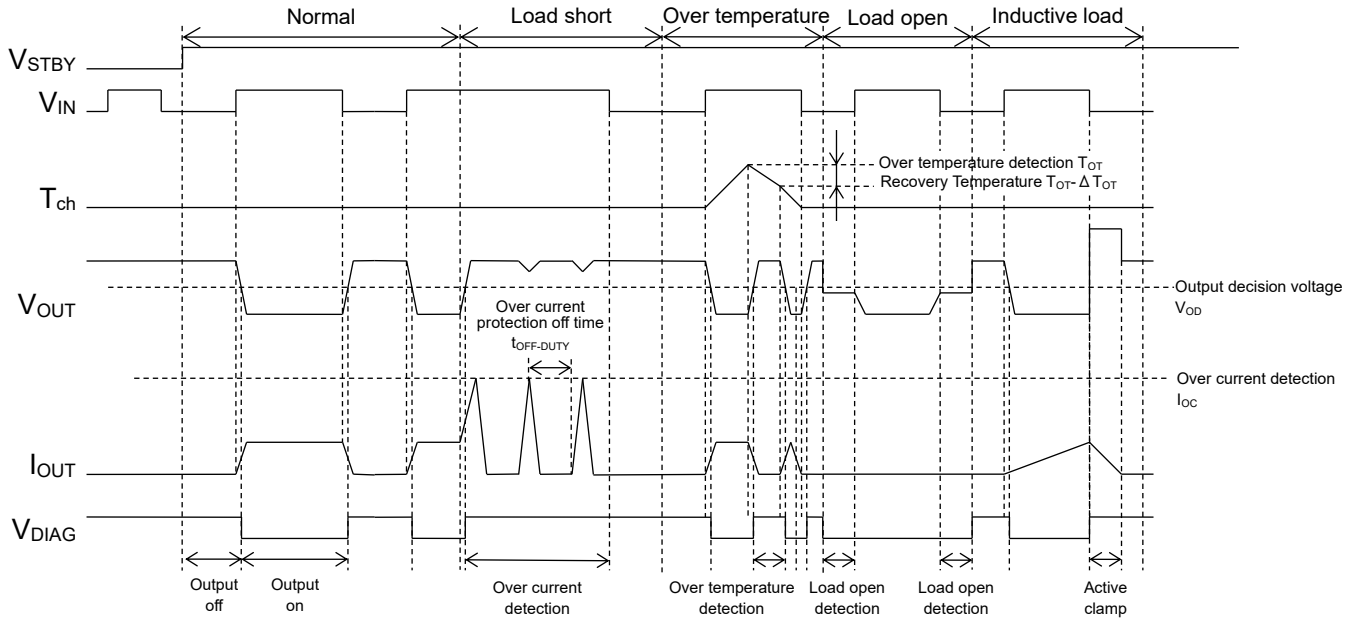


Figure 7.1 Timing chart

7.2. Truth table

Table 7.2 Truth table

STBY	IN	OUT	DIAG	Output DMOS	Operating state
L	L	H	H	OFF	Standby mode
	H	H	H	OFF	
H	L	H	H	OFF	Normal operation
	H	L	L	ON	
	L	H	H	OFF	Over current (Short to V_{BAT} / GND)
	H	H (Note 1)	H	ON/OFF	
	L	H	H	OFF	Over temperature
	H	H (Note 1)	H	OFF	
	L	L (Note 2)	L	OFF	Load open (Disconnection)
	H	L	L	ON	

Note 1: Case of STBY = H and IN = H, the output voltage conditions to output a diagnosis are more than V_{OD}. ($V_{OUT} > V_{OD}$)

Note 2: Case of STBY = H and IN = L, the output voltage conditions to output a diagnosis are less than V_{OD}. ($V_{OUT} < V_{OD}$)

8. Absolute Maximum Ratings

Table 8.1 Absolute Maximum Ratings (Note)

(T_a = 25 °C unless otherwise specified)

Characteristics	Symbol	PIN	Rating	Unit	Note
Supply voltage	V_{DD}	V_{DD}	−0.3 to 6.0	V	-
Input voltage	V_{IN}, V_{STBY}	IN, STBY	−0.3 to 6.0	V	-
Diagnosis output voltage	V_{DIAG}	DIAG	−0.3 to 6.0	V	-
Diagnosis output current	I_{DIAG}	DIAG	5.0	mA	-
Output voltage	V_{OUT}	OUT	−0.3 to 40.0	V	N channel DMOS (V_{DSS} = 60 V)
Output current	I_{OUT}	OUT	Internally Limited	A	-
Power dissipation (Note 3)	P_D	-	1.84	W	-
Single pulse active clamp capability (Note 4)	E_{AS}	-	95	mJ	-
Active clamp current	I_{AR}	OUT	6	A	-
Operating temperature	T_{opr}	-	−40 to 125	°C	-
Channel temperature	T_{ch}	-	150	°C	-
Storage temperature	T_{stg}	-	−40 to 150	°C	-

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 and the operating ranges.
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 3: Glass epoxy board
Material: FR-4 (4 layer)
Board size: 76.2 mm × 114.3 mm × 1.6 mm
Via: ⌀0.3 mm (2 point)

Note 4: Active clamp capability (single pulse) test condition
V_{BAT} = 12 V, T_{ch} = 25 °C (initial), L = 3.9 mH, I_{AR} = 6 A

9. Thermal Characteristics

Table 9.1 Thermal characteristics

Characteristics	Symbol	Rating	Unit
Thermal resistance, channel to ambient	$R_{th\ (ch\text{-}a)}$	67.6	°C/W

10. Electrical Characteristics

Table 10.1 Electrical Characteristics

(Unless otherwise specified T_{ch} = −40 to 125 °C, V_{DD} = 4.5 to 5.5 V)

Characteristics	Symbol	Pin	Test condition	Min	Typ. (Note 5)	Max	Unit
Output clamp voltage	$V_{(CL)DSS}$	OUT	I_{OUT} = 1m A, V_{STBY} = 5 V, V_{IN} = 0 V	40	46	60	V
Operating supply voltage	$V_{DD\ (opr)}$	V_{DD}	-	4.5	5.0	5.5	V
Under voltage protection	$V_{DD(UV)}$	V_{DD}	-	2.5	2.9	3.5	V
Supply current	I_{DD1}	V_{DD}	V_{STBY} = 0 V, V_{IN} = 0 V, V_{DD} = 5 V	-	0	10	μA
	I_{DD2}	V_{DD}	V_{STBY} = 5 V, V_{IN} = 0 V, V_{DD} = 5 V	-	0.61	2.00	mA
	I_{DD3}	V_{DD}	V_{STBY} = 5 V, V_{IN} = 5 V, V_{DD} = 5 V	-	0.62	5.00	mA
Output leakage current	I_{OL1}	OUT	V_{STBY} = V_{IL}, V_{IN} = V_{IL}, V_{OUT} = 8 to 16 V	-	-	10	μA
	I_{OL2}	OUT	V_{STBY} = V_{IH}, V_{IN} = V_{IL}, V_{OUT} = 8 to 16 V	-	160	300	μA
High level input voltage	V_{IH}	IN, STBY	-	2.0	-	-	V
Low level input voltage	V_{IL}	IN, STBY	-	-	-	0.8	V
High level input current	I_{IH}	IN, STBY	V_{STBY} = 5 V, V_{IN} = 5 V, V_{DD} = 5 V	-	50	200	μA
Low level input current	I_{IL}	IN, STBY	V_{STBY} = 0 V, V_{IN} = 0 V, V_{DD} = 5 V	-1	-	1	μA
DIAG leakage current	I_{DH}	DIAG	V_{DIAG} = 5 V	-	-	3	μA
DIAG output voltage	V_{DL}	DIAG	I_{DIAG} = +1 mA	-	0.01	0.20	V
Output resistance (output DMOS on)	$R_{DS(ON)1}$	OUT	I_{OUT} = +2 A, T_{ch} = 25 °C, V_{DD} = 5 V, V_{STBY} = V_{IH}, V_{IN} =V_{IH}	-	0.07	0.10	Ω
	$R_{DS(ON)2}$	OUT	I_{OUT} = +2 A, T_{ch} = -40 to 125 °C, V_{DD} = 5 V, V_{STBY} = V_{IH}, V_{IN} = V_{IH}	-	-	0.16	Ω
Overtemperature Detection	T_{OT}	-	V_{STBY} = V_{IH}, V_{IN} = V_{IH}	150	172	200	°C
	ΔT_{OT}	-		-	12	-	
Overcurrent detection	I_{OC}	OUT	V_{STBY} = V_{IH}, V_{IN} = V_{IH}, V_{DD} = 5 V	6	13	-	A
Over current protection off time	$t_{OFF-DUTY}$	OUT	V_{BAT} = 12 V, R_L = 0.1 Ω, V_{DD} = 5 V, V_{STBY} = V_{IH}, V_{IN} = V_{IH}	3	7	12	ms
Load open detection Resistance	R_{op}	OUT	V_{STBY} = V_{IH}, V_{IN} = V_{IL}, V_{OUT} = 8 to 16 V	10	300	1000	kΩ
	ΔR_{op}	OUT	V_{STBY} = V_{IH}, V_{IN} = V_{IL}, V_{OUT} = 8 to 16 V	-	40	-	kΩ
Output detection voltage	V_{OD}	OUT	V_{STBY} = V_{IH}, V_{OUT} = L → H	2	3	4	V
	ΔV_{OD}	OUT	V_{STBY} = V_{IH}	-	0.3	-	V
Output resistance (output DMOS off)	R_{OUT1}	OUT	V_{STBY} = V_{IH}, V_{IN} = V_{IL}, V_{DD} = 4.5 to 5.5 V T_{ch} = 25 °C	75	100	125	kΩ
	R_{OUT2}	OUT	V_{STBY} = V_{IH}, V_{IN} = V_{IL}, V_{DD} = 4.5 to 5.5 V T_{ch} = -40 to 125 °C	60	100	140	kΩ
Switching time	Δt_f	OUT	V_{STBY} = V_{IH}, V_{DD} = 5 V, T_{ch} = 25 °C, V_{BAT} = 12 V, R_L = 5 Ω, Slew rate: V_{OUT} 10% to 90%	7.0	16.4	-	V/μs
	t_{on}	OUT		-	0.8	5.0	μs
	Δt_r	OUT		7.0	15.5	-	V/μs
	t_{off}	OUT		-	2.1	5.0	μs

Note 5: The condition of the typical value is T_{ch} = 25 °C, V_{DD} = 5 V.

11. Test Circuit

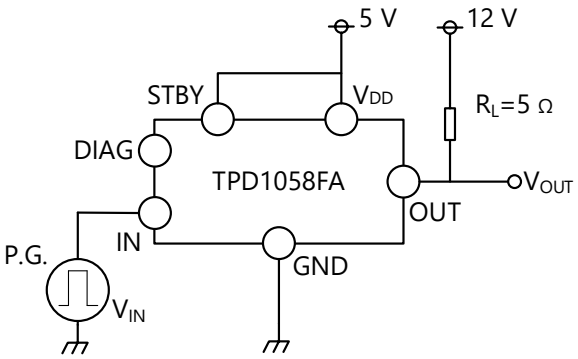


Figure 11.1 Test circuit 1 (Switching time test circuit)

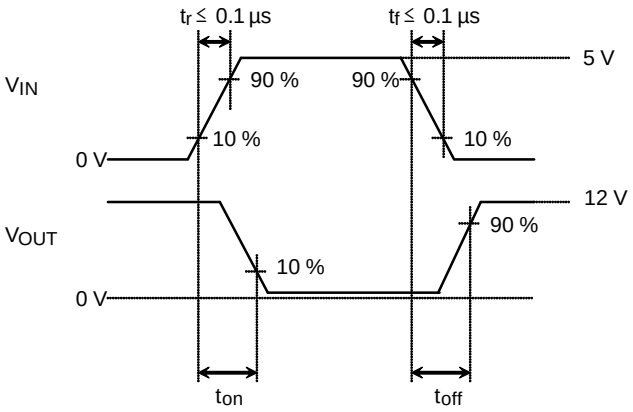


Figure 11.2 Switching time waveforms

12. Characteristic curves (Note)

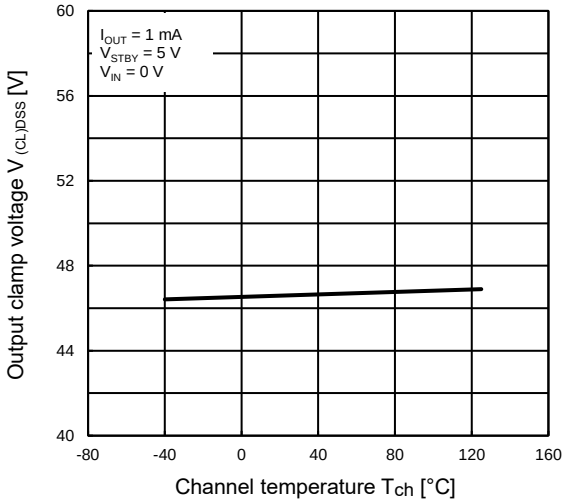


Figure 12.1 $V_{(CL)DSS}$ – T_{ch}

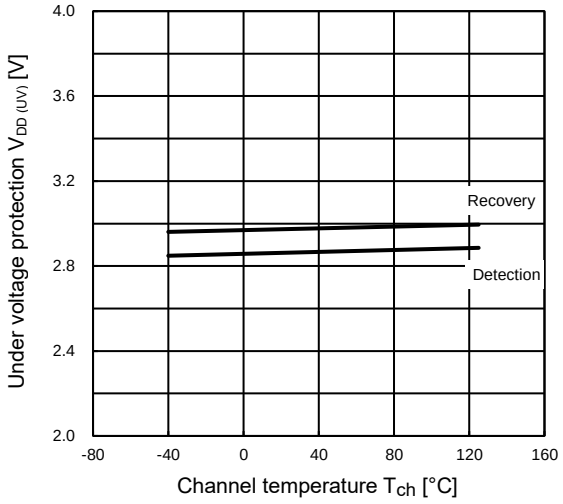


Figure 12.2 $V_{DD\ (UV)}$ – T_{ch}

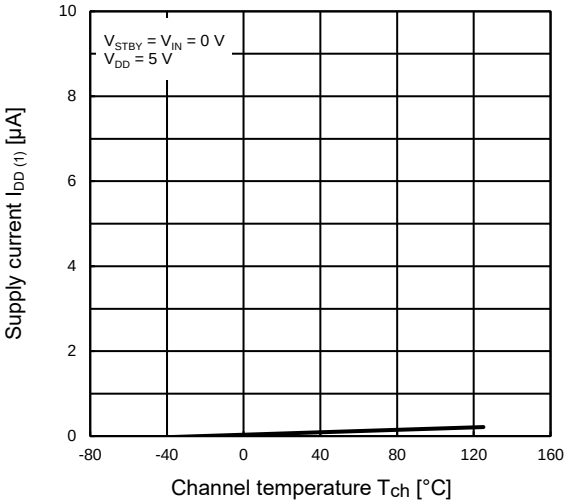


Figure 12.3 $I_{DD\ (1)}$ – T_{ch}

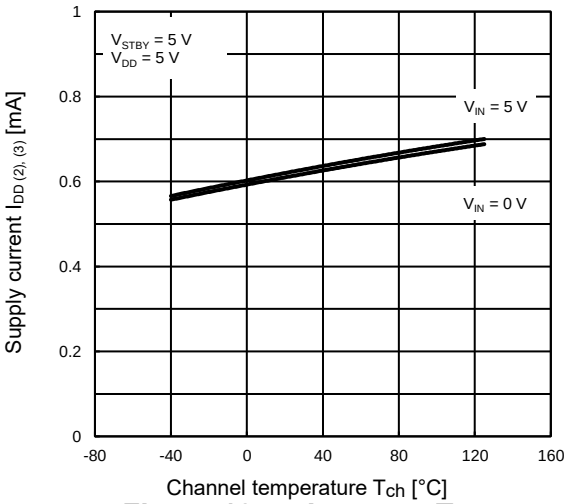


Figure 12.4 $I_{DD\ (2),\ (3)}$ – T_{ch}

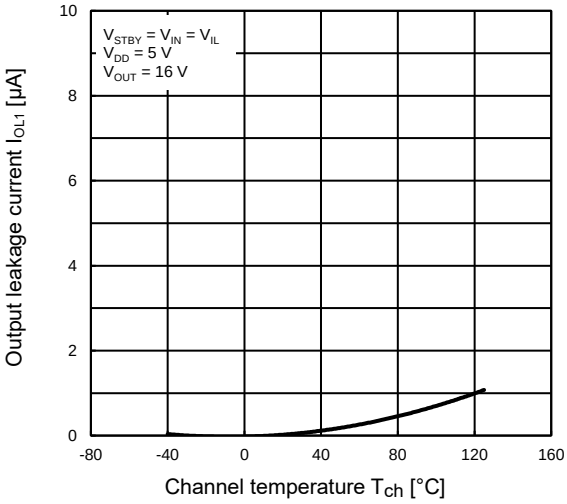


Figure 12.5 I_{OL1} – T_{ch}

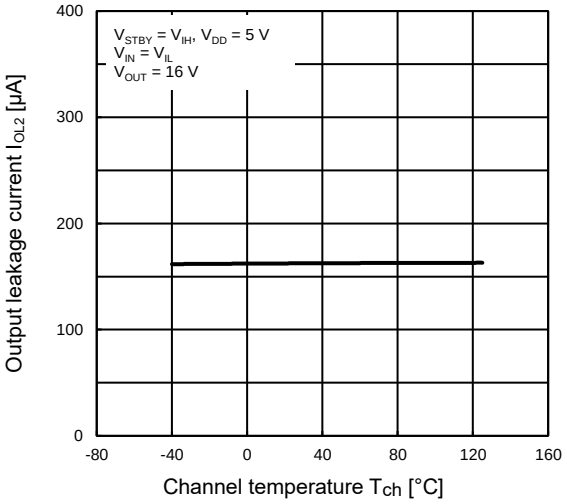


Figure 12.6 I_{OL2} – T_{ch}

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

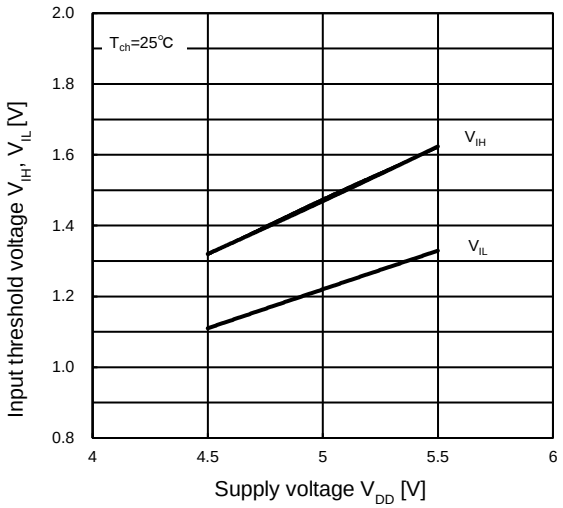


Figure 12.7 V_{IH}, V_{IL} – V_{DD}

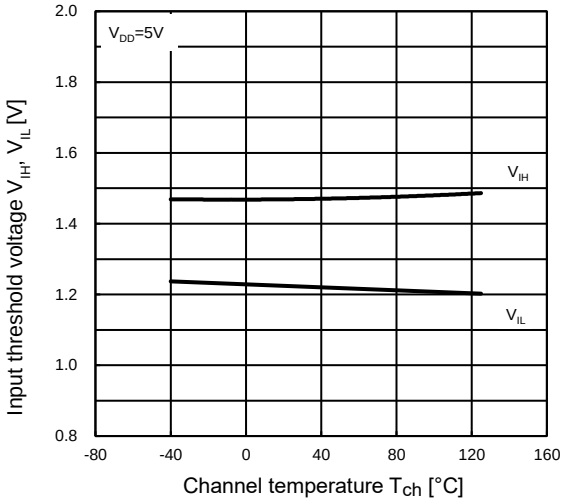


Figure 12.8 V_{IH}, V_{IL} – T_{ch}

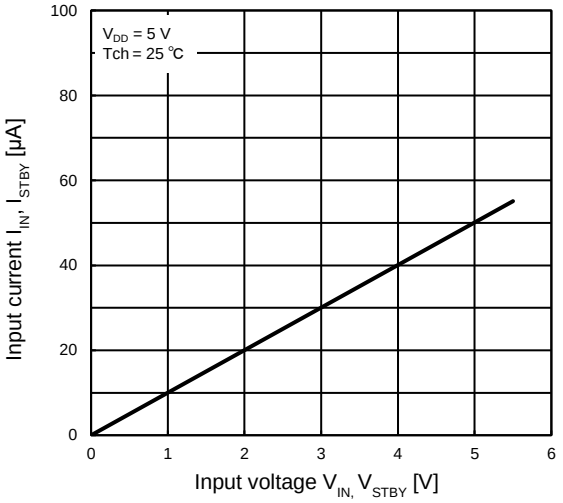


Figure 12.9 I_{IN} – V_{IN}

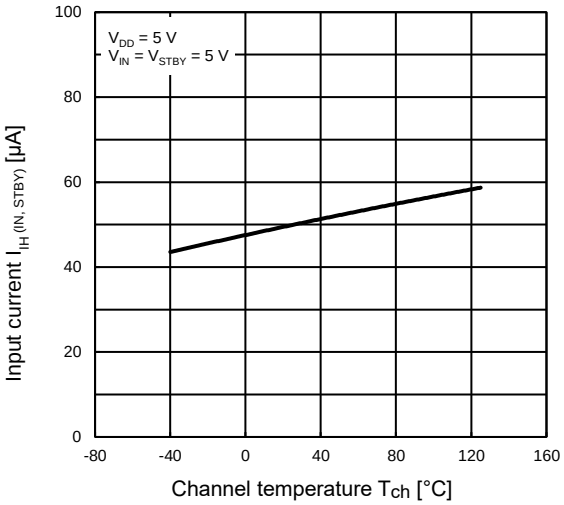


Figure 12.10 I_{IH} – T_{ch}

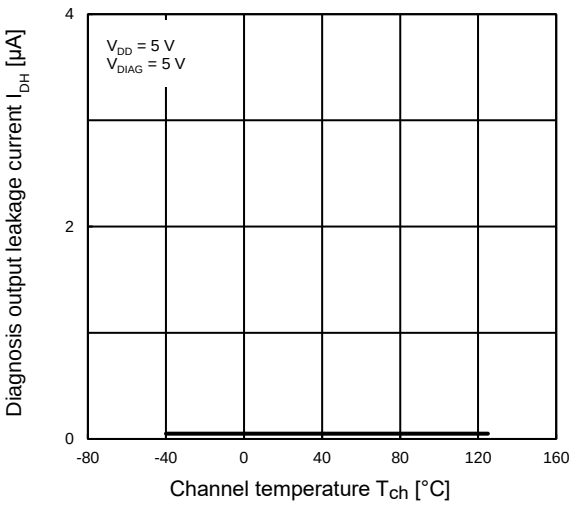


Figure 12.11 I_{DH} – T_{ch}

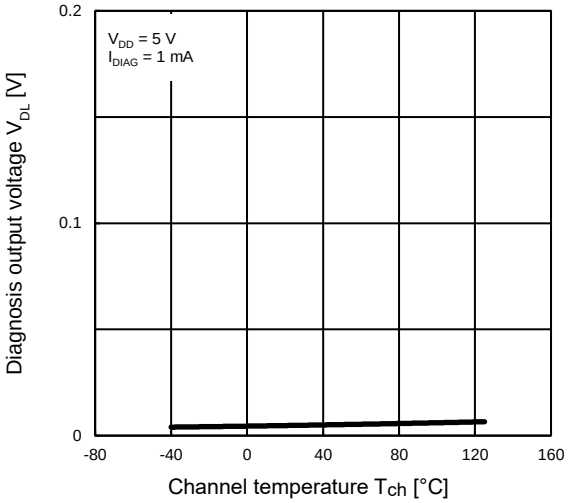


Figure 12.12 V_{DL} – T_{ch}

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

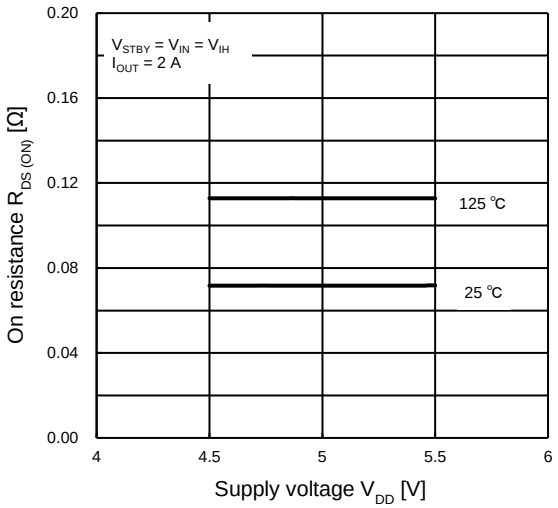


Figure 12.13 $R_{DS (ON)}$ – V_{DD}

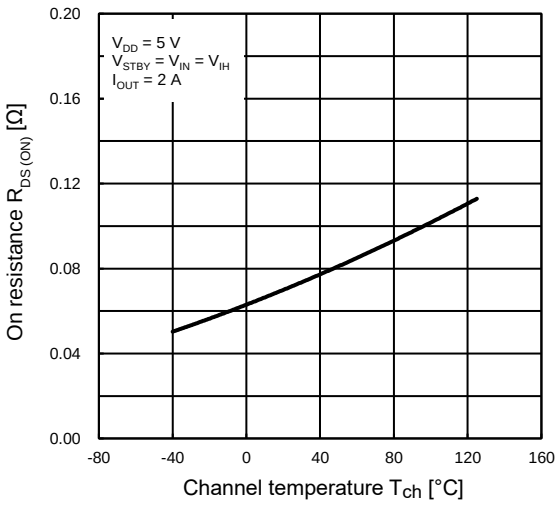


Figure 12.14 $R_{DS (ON)}$ – T_{ch}

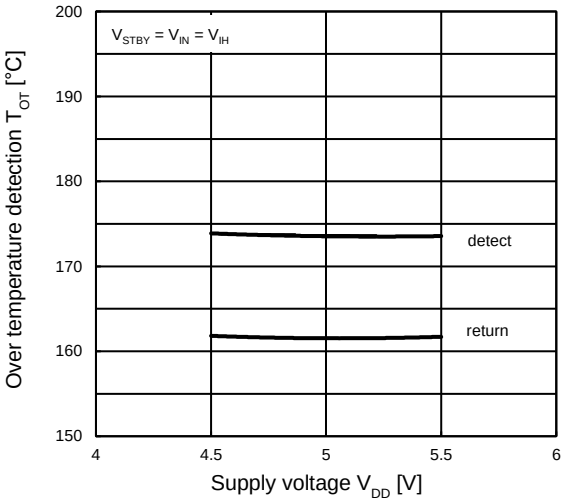


Figure 12.15 T_{OT} – V_{DD}

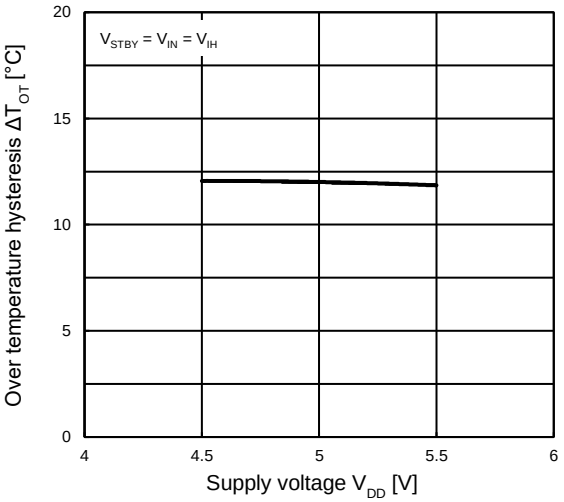


Figure 12.16 ΔT_{OT} – V_{DD}

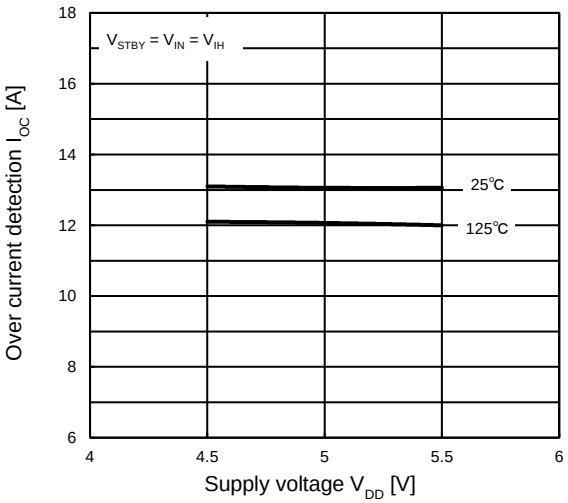


Figure 12.17 I_{OC} – V_{DD}

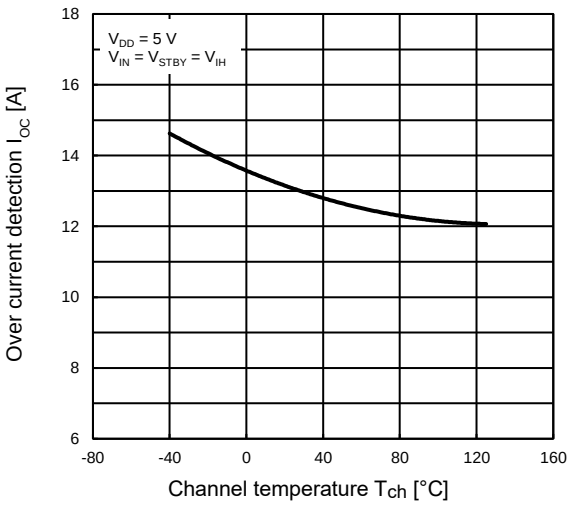


Figure 12.18 I_{OC} – T_{ch}

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

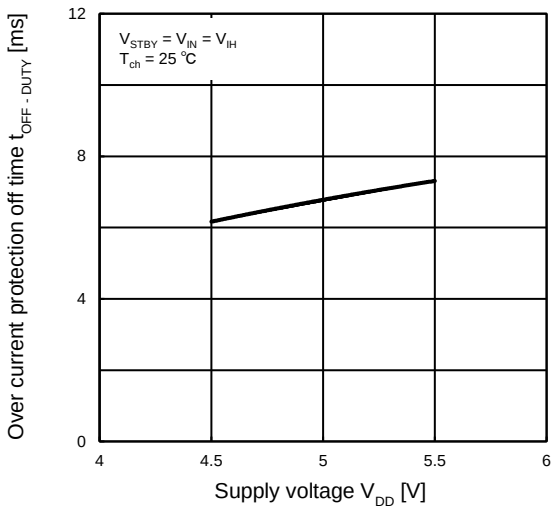


Figure 12.19 $t_{OFF\ -\ DUTY}$ – V_{DD}

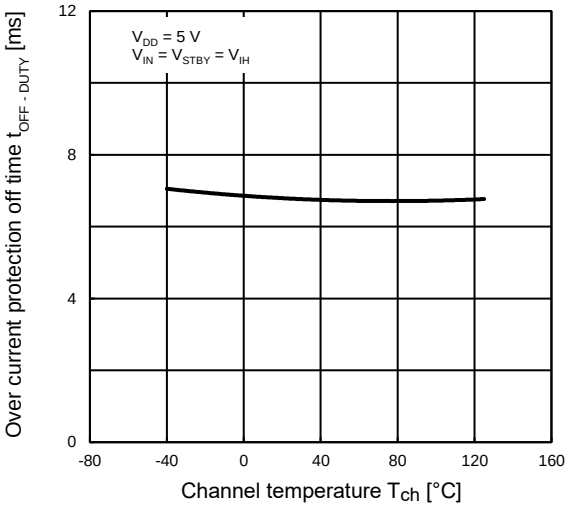


Figure 12.20 $t_{OFF\ -\ DUTY}$ – T_{ch}

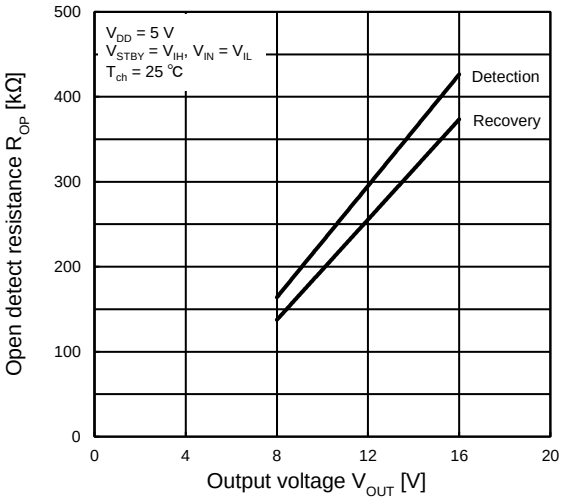


Figure 12.21 R_{OP} – V_{OUT}

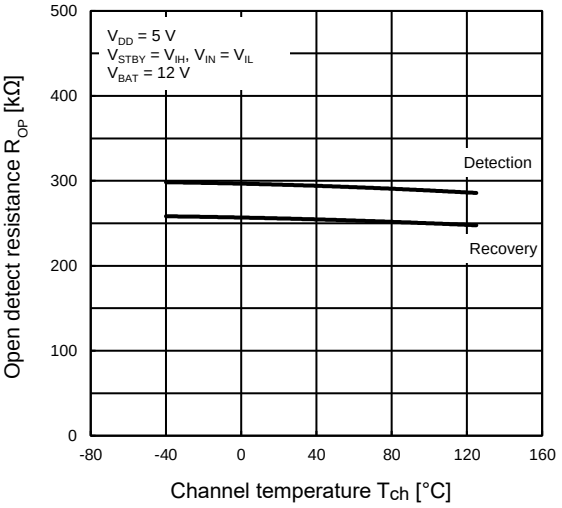


Figure 12.22 R_{OP} – T_{ch}

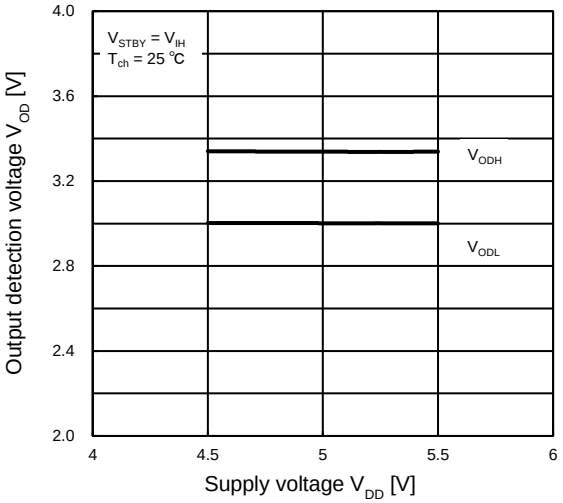


Figure 12.23 V_{OD} – V_{DD}

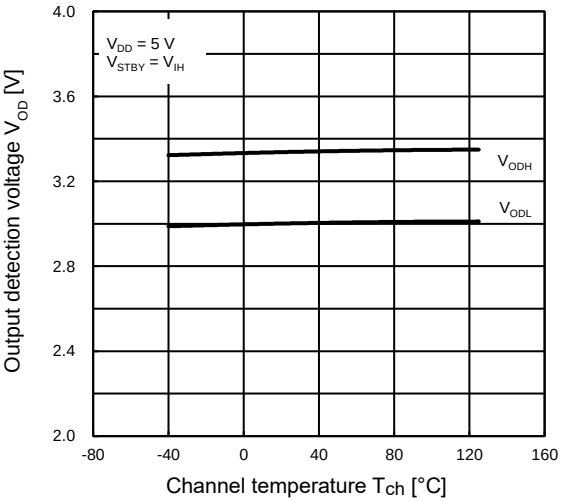


Figure 12.24 V_{OD} – T_{ch}

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

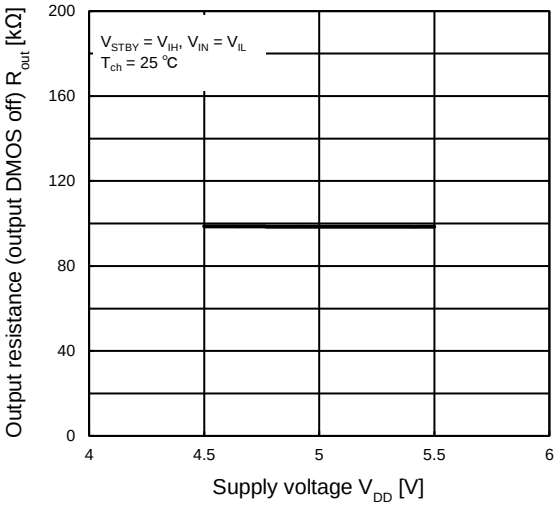


Figure 12.25 R_{out} – V_{DD}

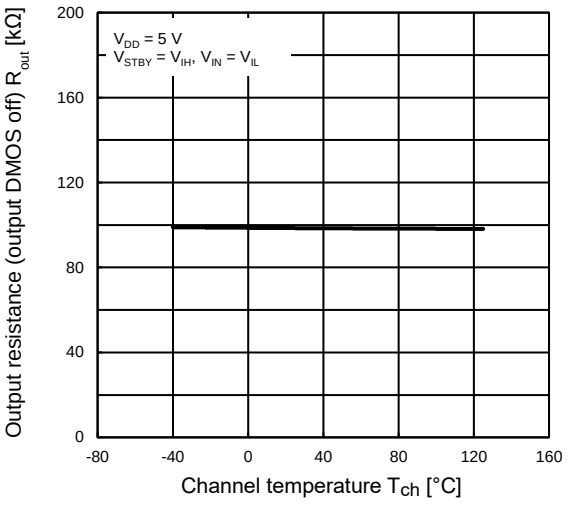


Figure 12.26 R_{out} – T_{ch}

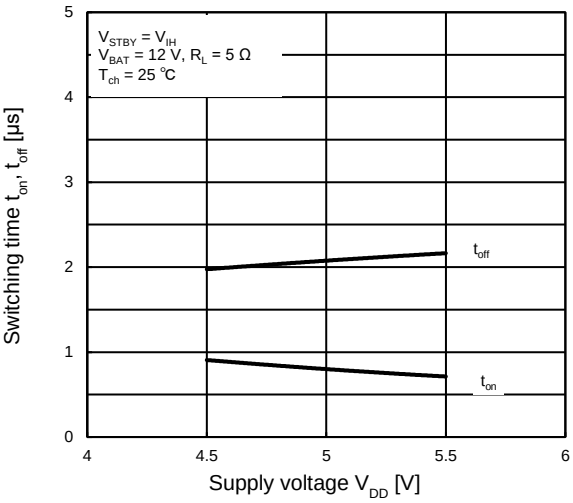


Figure 12.27 Switching time – V_{DD}

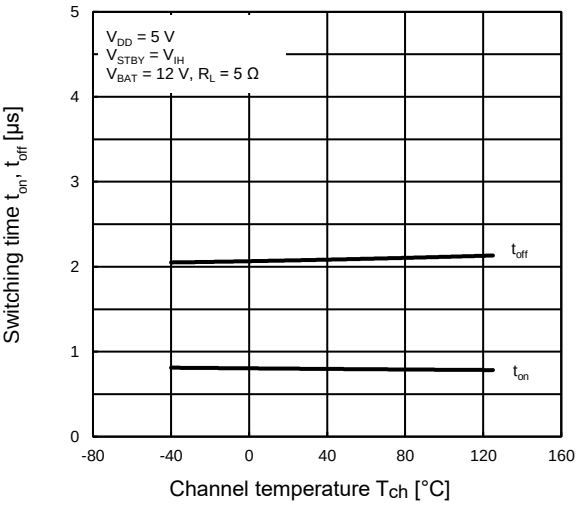


Figure 12.28 Switching time – T_{ch}

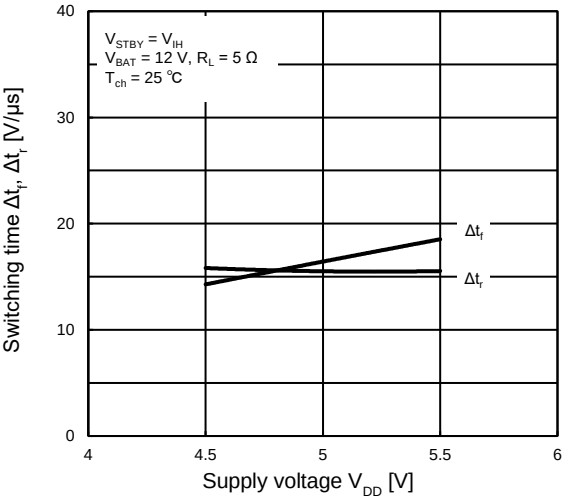


Figure 12.29 Switching time – V_{DD}

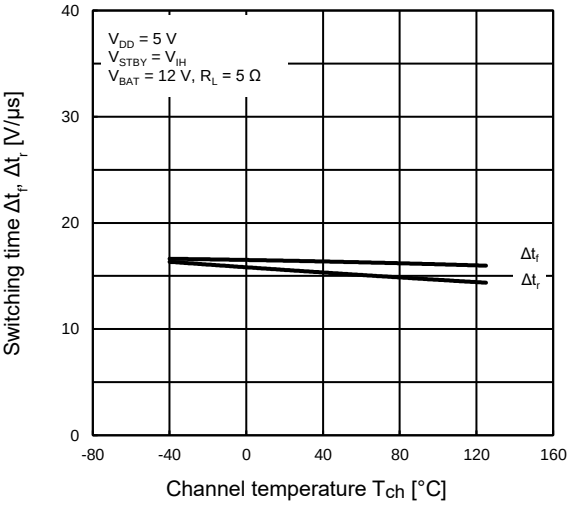


Figure 12.30 Switching time – T_{ch}

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

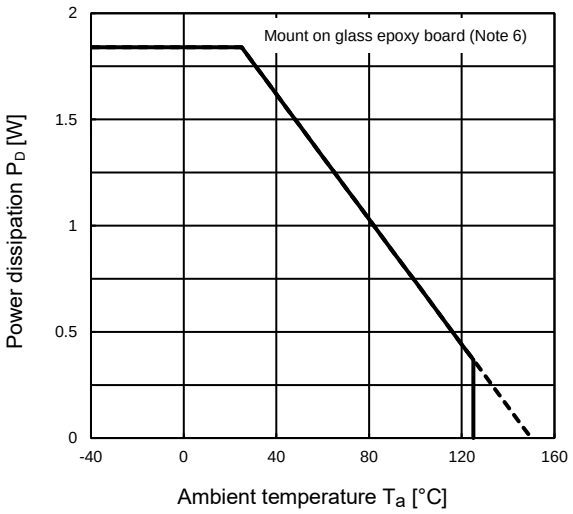


Figure 12.31 P_D – T_a

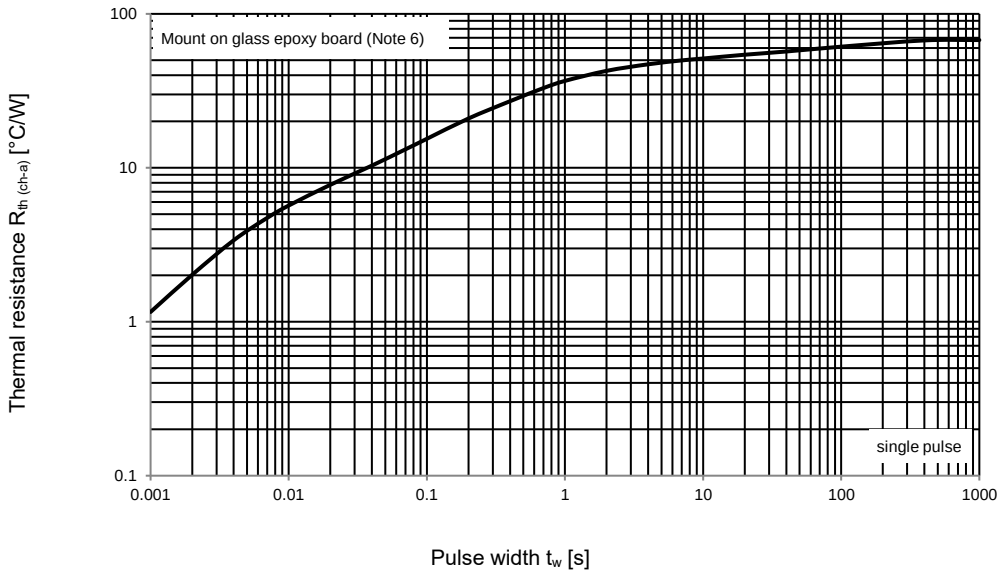


Figure 12.32 Switching time – t_w

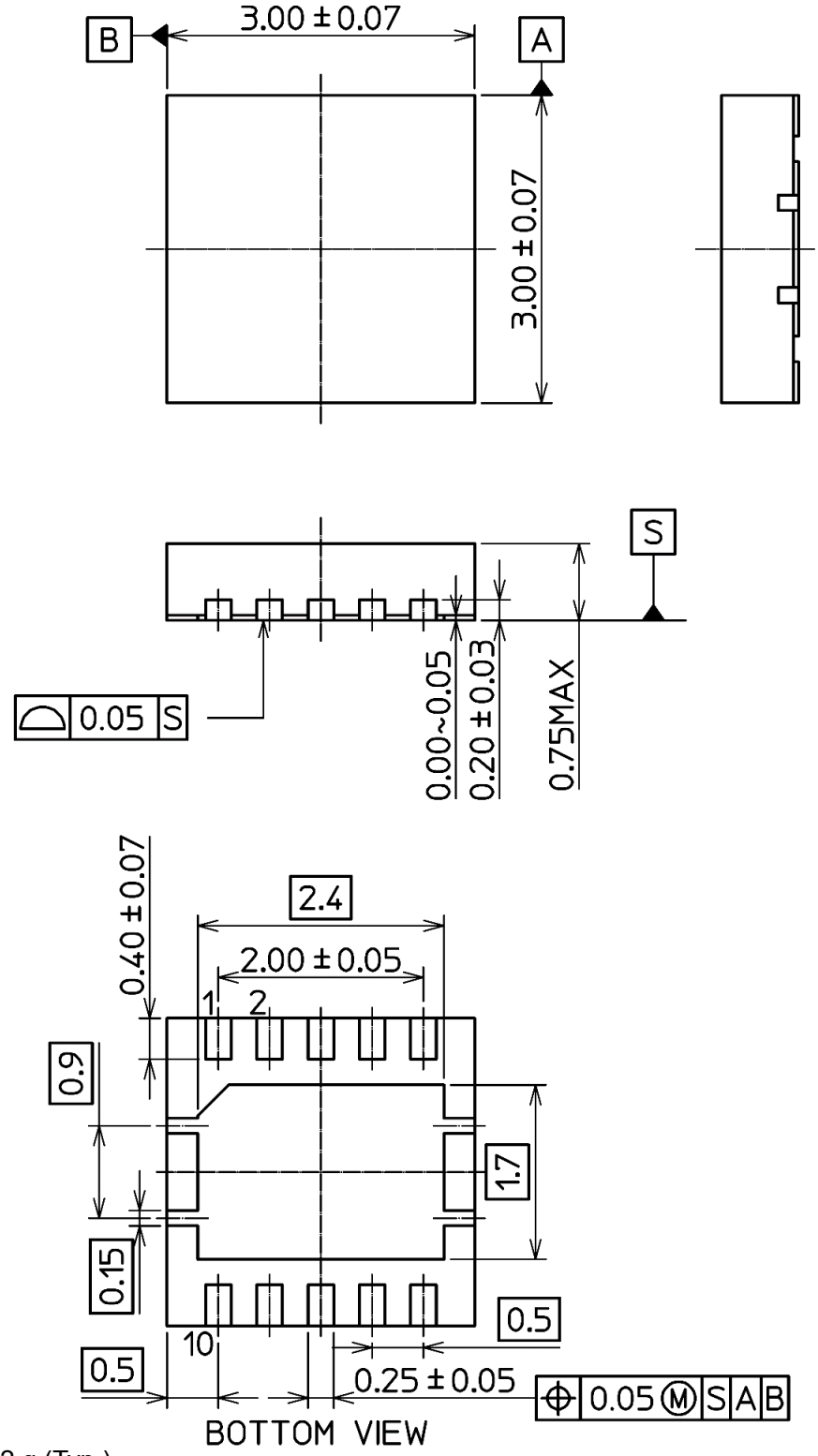
Note 6: Glass epoxy board
Material: FR-4 (4 layer)
Board size: 76.2 mm × 114.3 mm × 1.6 mm
Via: ⌀0.3 mm (2 point)

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

13. Package Information

13.1. Package Dimensions

P-WSON10-0303-0.50-001 Unit: mm



Weight: 0.02 g (Typ.)

Note: Please connect exposed pad to electrical open or GND.

13.2. Marking

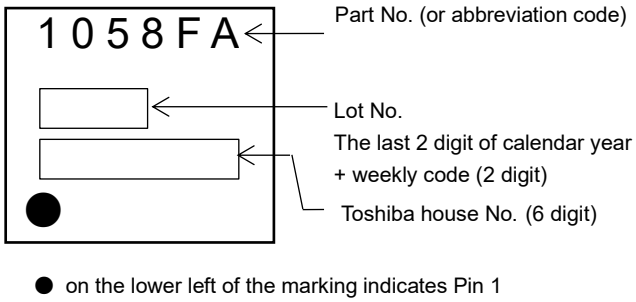


Figure 13.2 Marking

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