

# TPH1R403NL

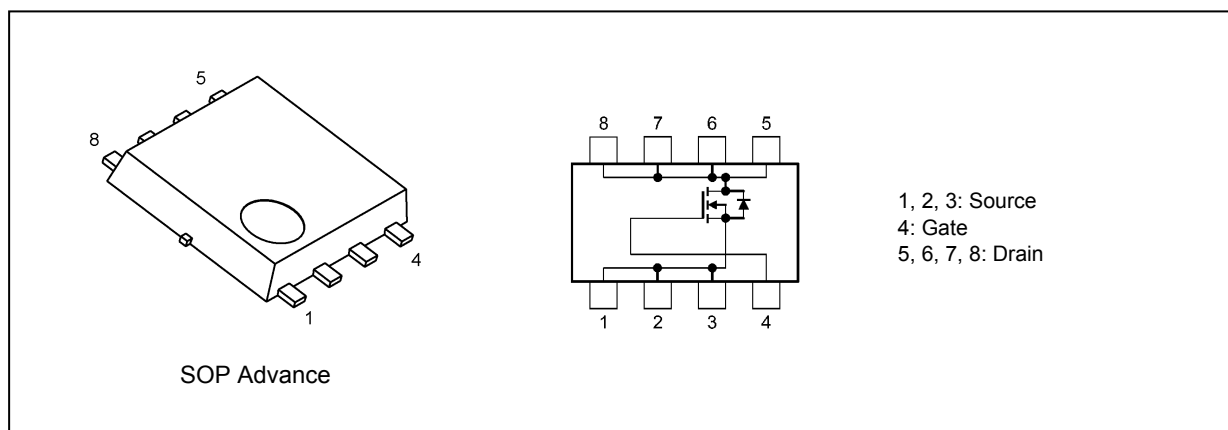
## 1. Applications

- High-Efficiency DC-DC Converters
- Switching Voltage Regulators

## 2. Features

- (1) High-speed switching
- (2) Small gate charge:  $Q_{SW} = 10.6 \text{ nC (typ.)}$
- (3) Low drain-source on-resistance:  $R_{DS(ON)} = 1.7 \text{ m}\Omega \text{ (typ.)}$  ( $V_{GS} = 4.5 \text{ V}$ )
- (4) Low leakage current:  $I_{DSS} = 10 \text{ }\mu\text{A (max)}$  ( $V_{DS} = 30 \text{ V}$ )
- (5) Enhancement mode:  $V_{th} = 1.3 \text{ to } 2.3 \text{ V}$  ( $V_{DS} = 10 \text{ V}$ ,  $I_D = 0.5 \text{ mA}$ )

## 3. Packaging and Internal Circuit



## 4. Absolute Maximum Ratings (Note) ( $T_a = 25 \text{ }^\circ\text{C}$ unless otherwise specified)

Characteristics	Symbol	Rating	Unit	
Drain-source voltage	$V_{DSS}$	30	V	
Gate-source voltage	$V_{GSS}$	$\pm 20$		
Drain current (DC)	(Silicon limit) (Note 1), (Note 2)	$I_D$	150	A
Drain current (DC)	( $T_c = 25 \text{ }^\circ\text{C}$ ) (Note 1)	$I_D$	60	
Drain current (pulsed)	( $t = 1 \text{ ms}$ ) (Note 1)	$I_{DP}$	200	
Power dissipation	( $T_c = 25 \text{ }^\circ\text{C}$ )	$P_D$	64	W
Power dissipation	( $t = 10 \text{ s}$ ) (Note 3)	$P_D$	2.8	
Power dissipation	( $t = 10 \text{ s}$ ) (Note 4)	$P_D$	1.6	
Single-pulse avalanche energy	(Note 5)	$E_{AS}$	355	mJ
Avalanche current		$I_{AR}$	60	A
Channel temperature		$T_{ch}$	150	$^\circ\text{C}$
Storage temperature		$T_{stg}$	-55 to 150	

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).

Start of commercial production  
2013-08

**5. Thermal Characteristics**

Characteristics	Symbol	Max	Unit
Channel-to-case thermal resistance (T <sub>c</sub> = 25 °C)	R <sub>th(ch-c)</sub>	1.95	°C/W
Channel-to-ambient thermal resistance (t = 10 s) (Note 3)	R <sub>th(ch-a)</sub>	44.6	
Channel-to-ambient thermal resistance (t = 10 s) (Note 4)	R <sub>th(ch-a)</sub>	78.1	

Note 1: Ensure that the channel temperature does not exceed 150 °C.

Note 2: Limited by silicon chip capability. Package limit is 60 A.

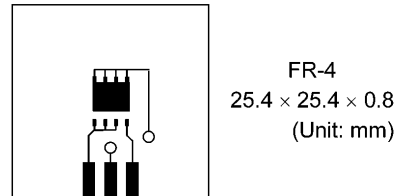
Note 3: Device mounted on a glass-epoxy board (a), Figure 5.1

Note 4: Device mounted on a glass-epoxy board (b), Figure 5.2

Note 5: V<sub>DD</sub> = 24 V, T<sub>ch</sub> = 25 °C (initial), L = 76 μH, I<sub>AR</sub> = 60 A



**Fig. 5.1 Device Mounted on a Glass-Epoxy Board (a)**



**Fig. 5.2 Device Mounted on a Glass-Epoxy Board (b)**

Note: This transistor is sensitive to electrostatic discharge and should be handled with care.

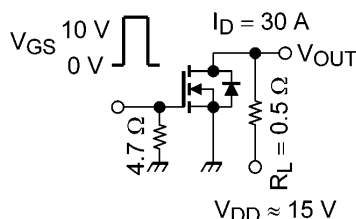
**6. Electrical Characteristics**

**6.1. Static Characteristics ( $T_a = 25\text{ }^\circ\text{C}$  unless otherwise specified)**

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Gate leakage current	$I_{GSS}$	$V_{GS} = \pm 20\text{ V}, V_{DS} = 0\text{ V}$	—	—	$\pm 0.1$	$\mu\text{A}$
Drain cut-off current	$I_{DSS}$	$V_{DS} = 30\text{ V}, V_{GS} = 0\text{ V}$	—	—	10	
Drain-source breakdown voltage	$V_{(BR)DSS}$	$I_D = 10\text{ mA}, V_{GS} = 0\text{ V}$	30	—	—	V
	$V_{(BR)DSX}$	$I_D = 10\text{ mA}, V_{GS} = -20\text{ V}$	15	—	—	
Gate threshold voltage	$V_{th}$	$V_{DS} = 10\text{ V}, I_D = 0.5\text{ mA}$	1.3	—	2.3	
Drain-source on-resistance	$R_{DS(ON)}$	$V_{GS} = 4.5\text{ V}, I_D = 30\text{ A}$	—	1.7	2.1	$\text{m}\Omega$
		$V_{GS} = 10\text{ V}, I_D = 30\text{ A}$	—	1.2	1.4	

**6.2. Dynamic Characteristics ( $T_a = 25\text{ }^\circ\text{C}$  unless otherwise specified)**

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Input capacitance	$C_{iss}$	$V_{DS} = 15\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	—	3400	4400	$\text{pF}$
Reverse transfer capacitance	$C_{rss}$		—	93	200	
Output capacitance	$C_{oss}$		—	1800	—	
Gate resistance	$r_g$	—	—	1.1	1.7	$\Omega$
Switching time (rise time)	$t_r$	See Fig. 6.2.1	—	5.6	—	ns
Switching time (turn-on time)	$t_{on}$		—	16	—	
Switching time (fall time)	$t_f$		—	8.9	—	
Switching time (turn-off time)	$t_{off}$		—	50	—	



Duty  $\leq 1\%$ ,  $t_w = 10\text{ }\mu\text{s}$

**Fig. 6.2.1 Switching Time Test Circuit**

**6.3. Gate Charge Characteristics ( $T_a = 25\text{ }^\circ\text{C}$  unless otherwise specified)**

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Total gate charge (gate-source plus gate-drain)	$Q_g$	$V_{DD} \approx 15\text{ V}, V_{GS} = 10\text{ V}, I_D = 60\text{ A}$	—	46	—	nC
		$V_{DD} \approx 15\text{ V}, V_{GS} = 4.5\text{ V}, I_D = 60\text{ A}$	—	20	—	
Gate-source charge 1	$Q_{gs1}$	$V_{DD} \approx 15\text{ V}, V_{GS} = 10\text{ V}, I_D = 60\text{ A}$	—	12.1	—	
Gate-drain charge	$Q_{gd}$		—	4.3	—	
Gate switch charge	$Q_{SW}$		—	10.6	—	

**6.4. Source-Drain Characteristics ( $T_a = 25\text{ }^\circ\text{C}$  unless otherwise specified)**

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Reverse drain current (pulsed)	(Note 6) $I_{DRP}$	—	—	—	200	A
Diode forward voltage	$V_{DSF}$	$I_{DR} = 60\text{ A}, V_{GS} = 0\text{ V}$	—	—	-1.2	V

Note 6: Ensure that the channel temperature does not exceed  $150\text{ }^\circ\text{C}$ .

7. Marking

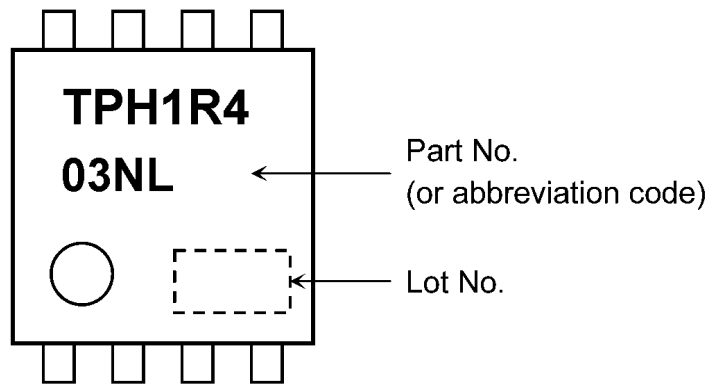
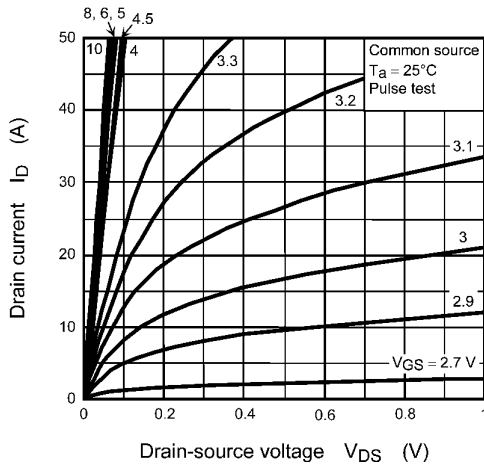
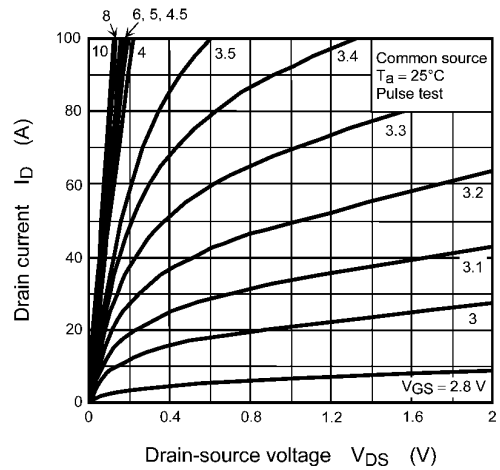


Fig. 7.1 Marking

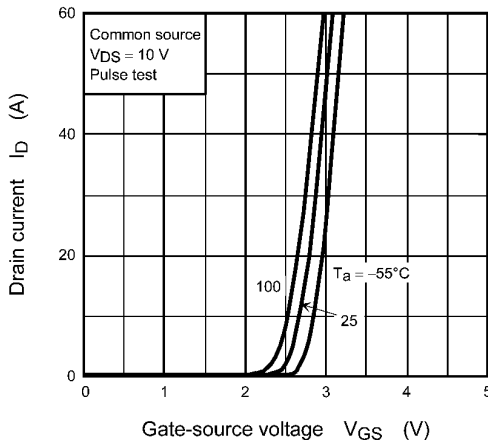
**8. Characteristics Curves (Note)**



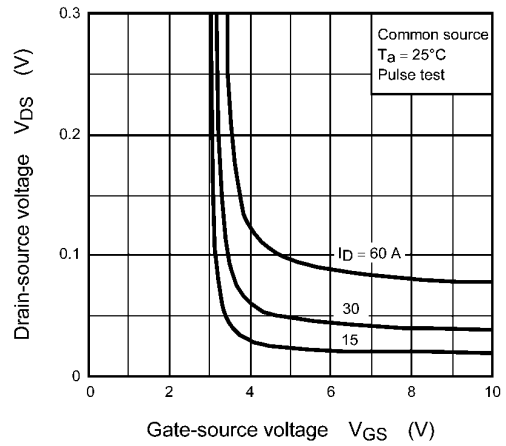
**Fig. 8.1 ID - VDS**



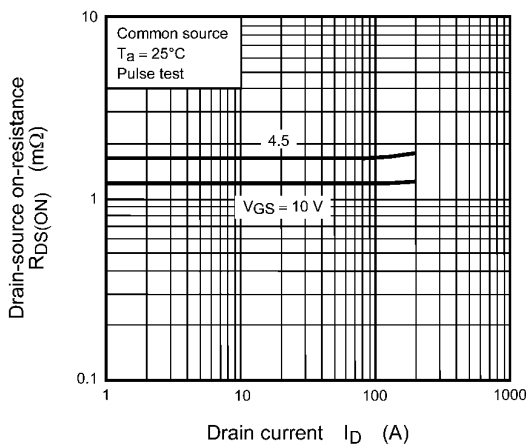
**Fig. 8.2 ID - VDS**



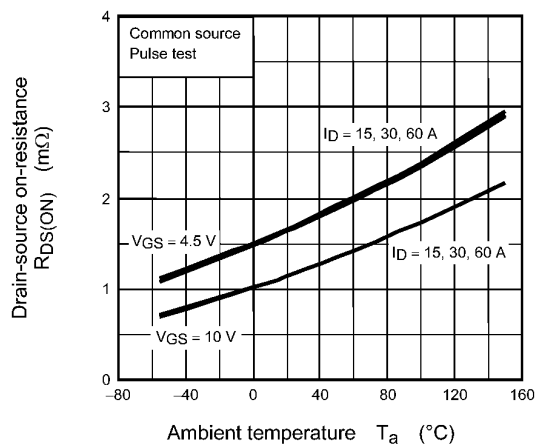
**Fig. 8.3 ID - VGS**



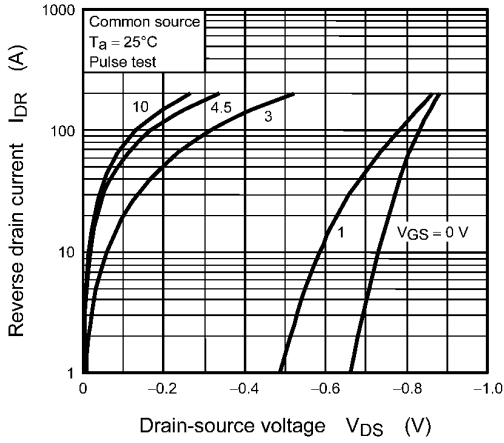
**Fig. 8.4 VDS - VGS**



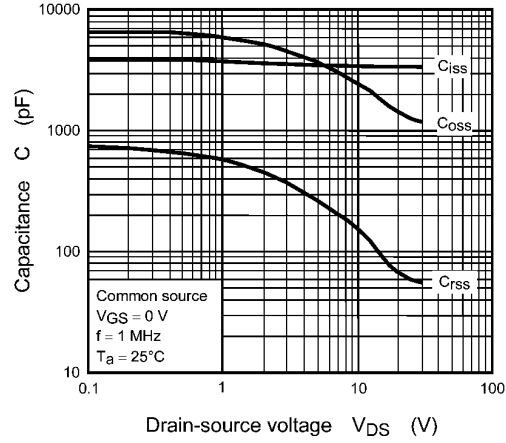
**Fig. 8.5 RDS(ON) - ID**



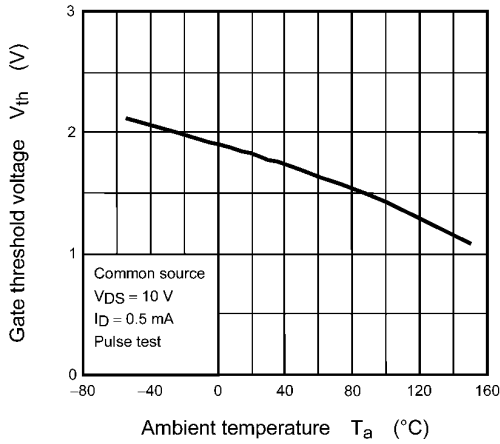
**Fig. 8.6 RDS(ON) - Ta**



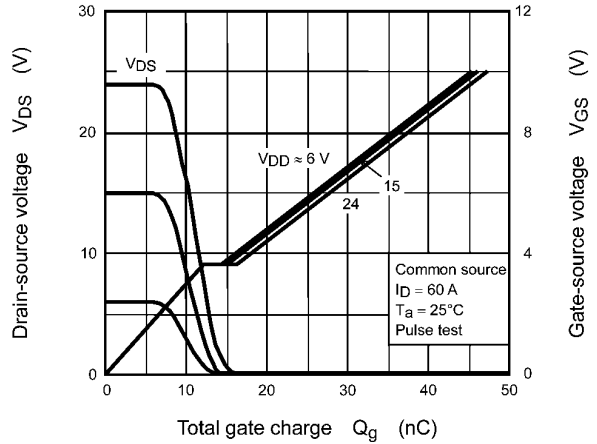
**Fig. 8.7  $I_{DR} - V_{DS}$**



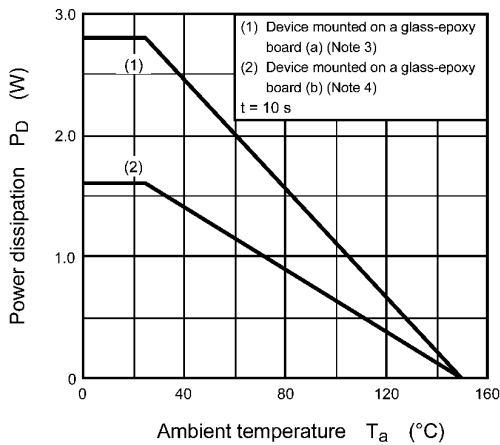
**Fig. 8.8 Capacitance -  $V_{DS}$**



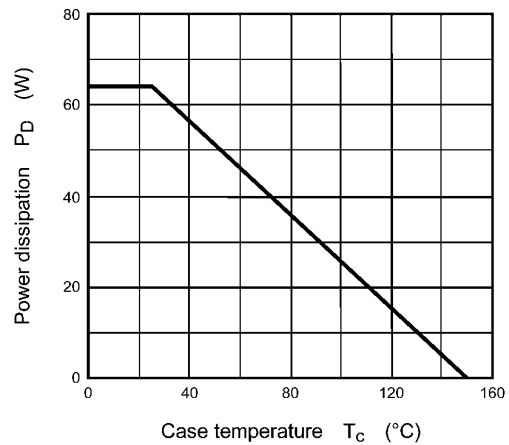
**Fig. 8.9  $V_{th} - T_a$**



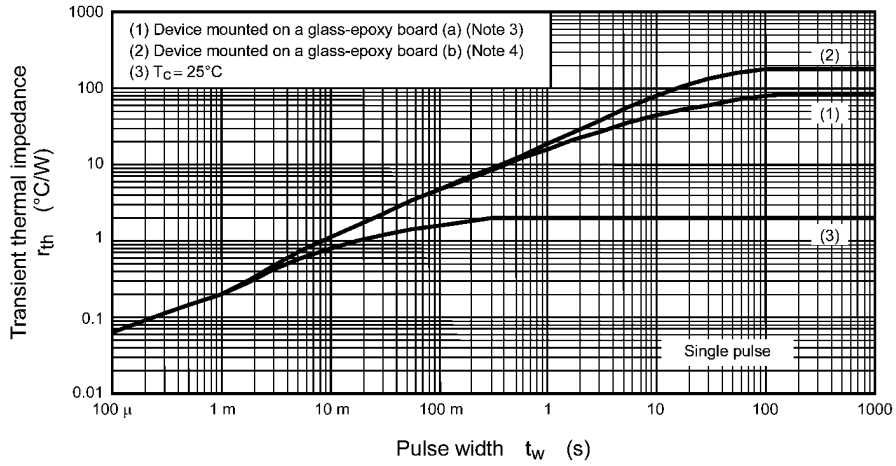
**Fig. 8.10 Dynamic Input/Output Characteristics**



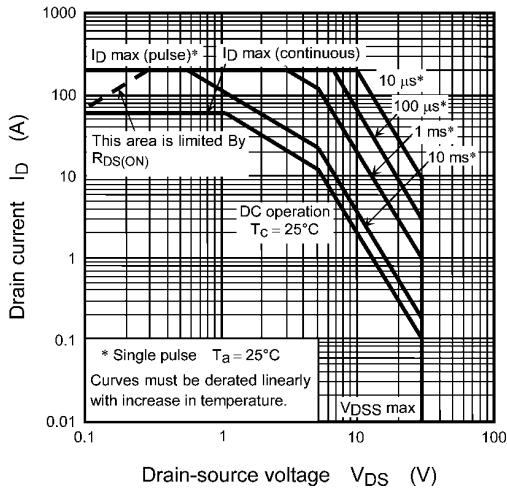
**Fig. 8.11  $P_D - T_a$   
(Guaranteed Maximum)**



**Fig. 8.12  $P_D - T_c$   
(Guaranteed Maximum)**



**Fig. 8.13  $r_{th} - t_w$**   
(Guaranteed Maximum)



**Fig. 8.14 Safe Operating Area**  
(Guaranteed Maximum)

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

**Package Dimensions**

Unit: mm



Weight: 0.069 g (typ.)

Package Name(s)
TOSHIBA: 2-5Q1S
Nickname: SOP Advance



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