

# TPH1R403NL

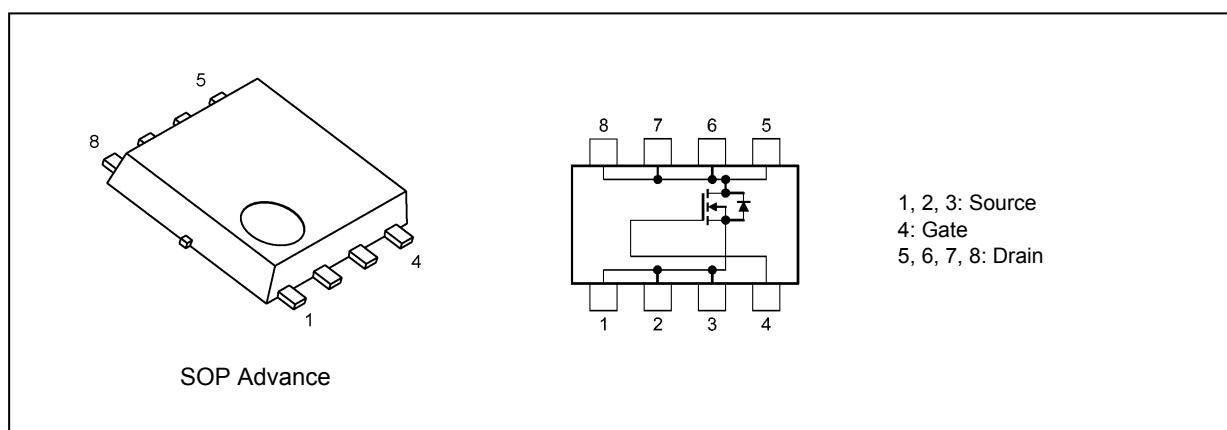
## 1. Applications

- 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.

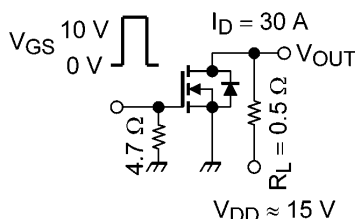
**6. Electrical Characteristics**

**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

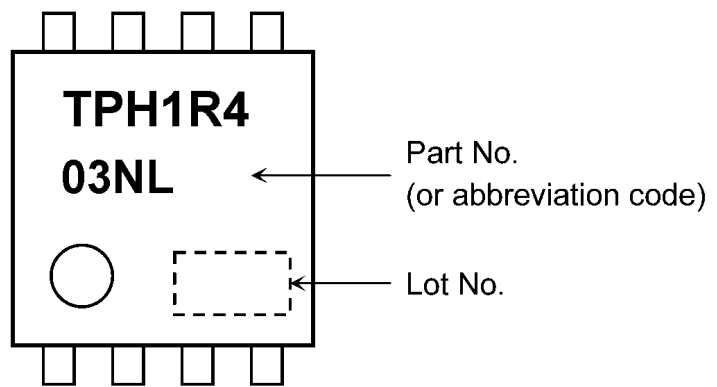
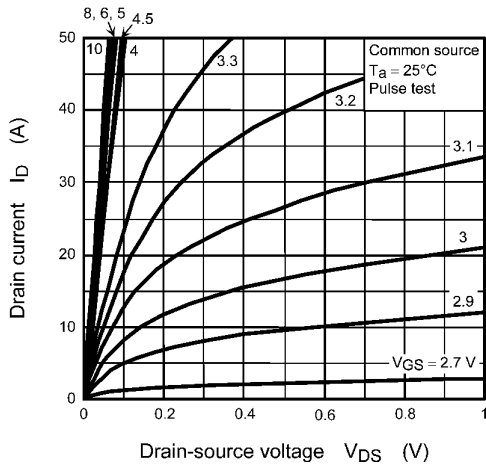
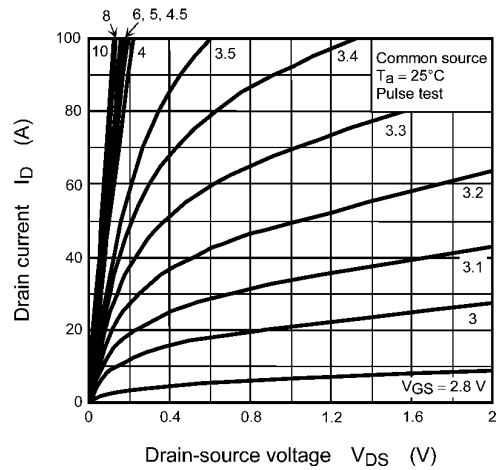


Fig. 7.1 Marking

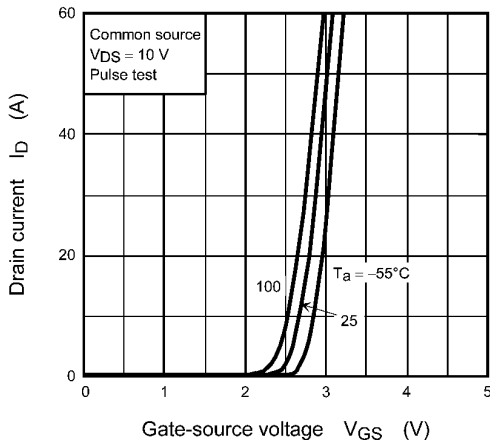
**8. Characteristics Curves (Note)**



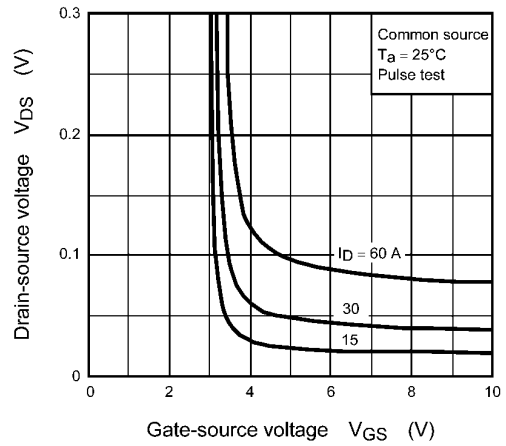
**Fig. 8.1  $I_D - V_{DS}$**



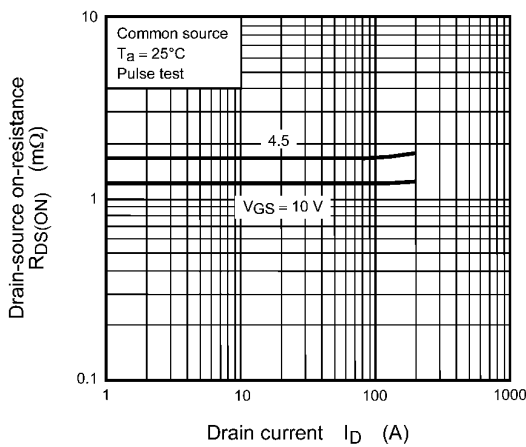
**Fig. 8.2  $I_D - V_{DS}$**



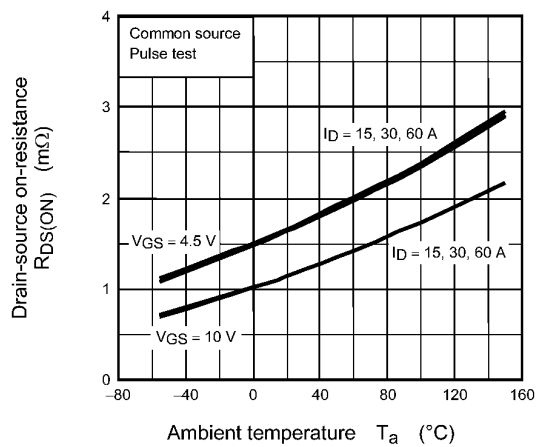
**Fig. 8.3  $I_D - V_{GS}$**



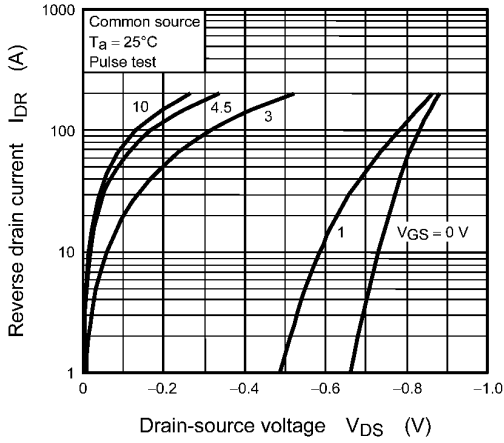
**Fig. 8.4  $V_{DS} - V_{GS}$**



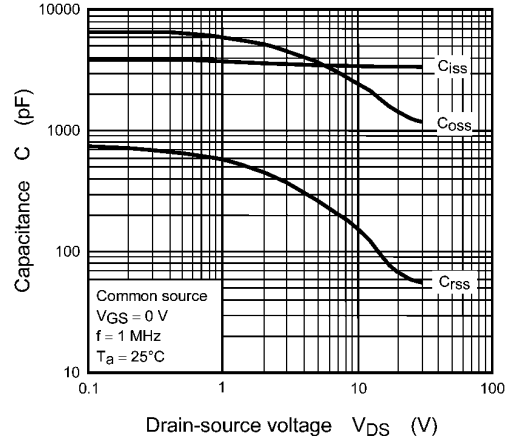
**Fig. 8.5  $R_{DS(ON)} - I_D$**



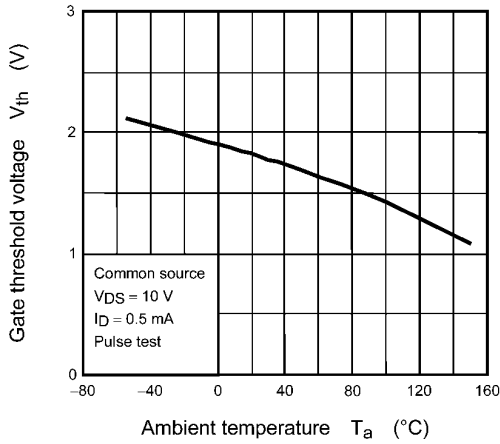
**Fig. 8.6  $R_{DS(ON)} - T_a$**



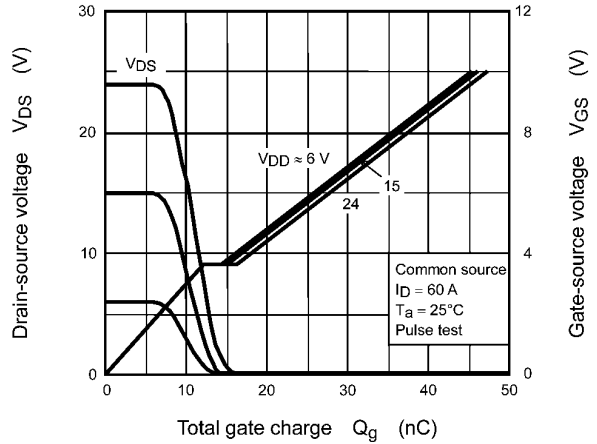
**Fig. 8.7  $I_{DR} - V_{DS}$**



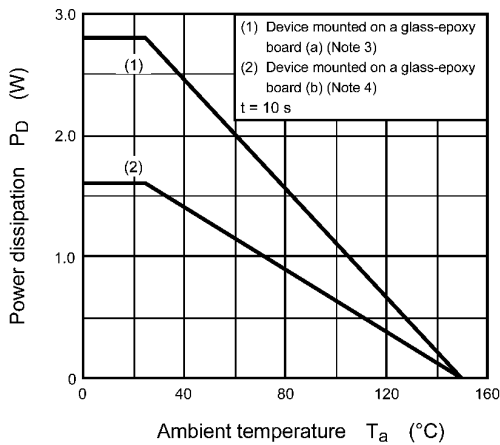
**Fig. 8.8 Capacitance -  $V_{DS}$**



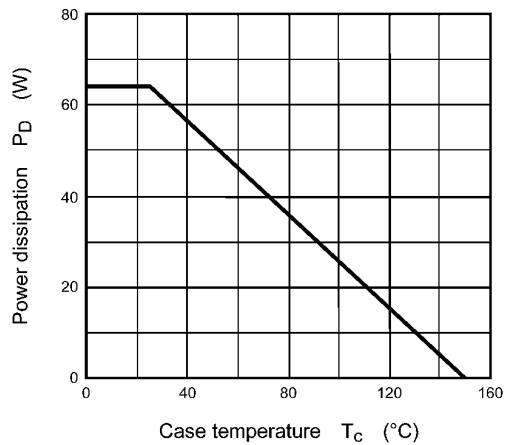
**Fig. 8.9  $V_{th} - T_a$**



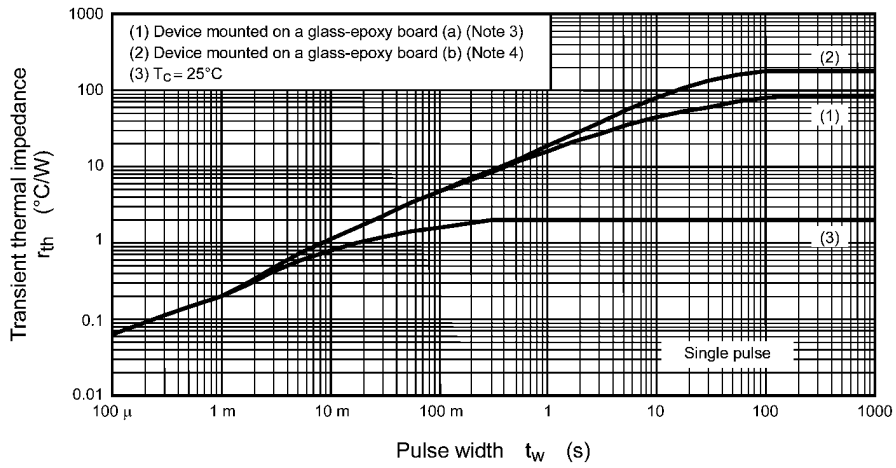
**Fig. 8.10 Dynamic Input/Output Characteristics**



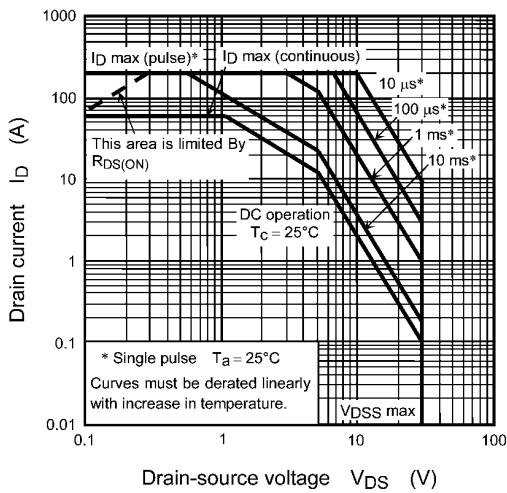
**Fig. 8.11  $P_D - T_a$   
(Guaranteed Maximum)**



**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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