TPHR7904PB

1. Applications
   - Automotive
   - Motor Drivers
   - Switching Voltage Regulators

2. Features
   (1) AEC-Q101 qualified
   (2) Small, thin package
   (3) Low drain-source on resistance: $R_{DS(ON)} = 0.65 \text{ m} \Omega$ (typ.) ($V_{GS} = 10 \text{ V}$)
   (4) Low leakage current: $I_{DSS} = 10 \mu\text{A}$ (max) ($V_{DS} = 40 \text{ V}$)
   (5) Enhancement mode: $V_{TH} = 2.0$ to $3.0 \text{ V}$ ($V_{DS} = 10 \text{ V}$, $I_{D} = 1.0 \text{ mA}$)

3. Packaging and Internal Circuit

![SOP Advance(WF) Diagram]

1, 2, 3: Source
4: Gate
5, 6, 7, 8: Drain

Start of commercial production
2018-03
4. Absolute Maximum Ratings (Note) (\(T_a = 25 \, ^\circ\text{C}\) unless otherwise specified)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain-source voltage</td>
<td>(V_{DSS})</td>
<td>40</td>
<td>V</td>
</tr>
<tr>
<td>Gate-source voltage</td>
<td>(V_{GSS})</td>
<td>±20</td>
<td></td>
</tr>
<tr>
<td>Drain current (DC) (Note 1)</td>
<td>(I_D)</td>
<td>150</td>
<td>A</td>
</tr>
<tr>
<td>Drain current (pulsed) (Note 1)</td>
<td>(I_{OP})</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>Power dissipation ((T_c = 25 , ^\circ\text{C}))</td>
<td>(P_D)</td>
<td>170</td>
<td>W</td>
</tr>
<tr>
<td>Power dissipation ((t = 10 , \text{s})) (Note 2)</td>
<td>(P_D)</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Power dissipation ((t = 10 , \text{s})) (Note 3)</td>
<td>(P_D)</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>Single-pulse avalanche energy</td>
<td>(E_{AS})</td>
<td>287</td>
<td>mJ</td>
</tr>
<tr>
<td>Single-pulse avalanche current</td>
<td>(I_{AS})</td>
<td>150</td>
<td>A</td>
</tr>
<tr>
<td>Channel temperature (Note 5)</td>
<td>(T_{ch})</td>
<td>175</td>
<td>(^\circ\text{C})</td>
</tr>
<tr>
<td>Storage temperature (Note 5)</td>
<td>(T_{stg})</td>
<td>-55 to 175</td>
<td></td>
</tr>
</tbody>
</table>

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).

5. Thermal Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel-to-case thermal impedance ((T_c = 25 , ^\circ\text{C}))</td>
<td>(z_{th(ch-c)})</td>
<td>0.88</td>
<td>(^\circ\text{C}/\text{W})</td>
</tr>
<tr>
<td>Channel-to-ambient thermal impedance ((t = 10 , \text{s})) (Note 2)</td>
<td>(z_{th(ch-a)})</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Channel-to-ambient thermal impedance ((t = 10 , \text{s})) (Note 3)</td>
<td>(z_{th(ch-a)})</td>
<td>156</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Ensure that the channel temperature does not exceed 175 \(^\circ\text{C}\).
Note 2: Device mounted on a glass-epoxy board (a), Figure 5.1
Note 3: Device mounted on a glass-epoxy board (b), Figure 5.2
Note 4: \(V_{DD} = 32 \, \text{V}, \, T_{ch} = 25 \, ^\circ\text{C}\) (initial), \(L = 9.8 \, \mu\text{H}, \, R_G = 25 \, \Omega, \, I_{AS} = 150 \, \text{A}\)
Note 5: The definitions of the absolute maximum channel and storage temperatures are qualified per AEC-Q101.

![Fig. 5.1 Device Mounted on a Glass-Epoxy Board (a)](image1)

![Fig. 5.2 Device Mounted on a Glass-Epoxy Board (b)](image2)

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

6.1. Static Characteristics ($T_a = 25 \, ^\circ C$ unless otherwise specified)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Min</th>
<th>Typ.</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate leakage current</td>
<td>$I_{GS}$</td>
<td>$V_{GS} = \pm 20 , V, , V_{DS} = 0 , V$</td>
<td>—</td>
<td>—</td>
<td>±1</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>Drain cut-off current</td>
<td>$I_{DS}$</td>
<td>$V_{DS} = 40 , V, , V_{GS} = 0 , V$</td>
<td>—</td>
<td>—</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Drain-source breakdown voltage</td>
<td>$V_{BR(ODS)}$</td>
<td>$I_D = 10 , mA, , V_{GS} = 0 , V$</td>
<td>40</td>
<td>—</td>
<td>—</td>
<td>$V$</td>
</tr>
<tr>
<td></td>
<td>$V_{BR(ODS)}$</td>
<td>$I_D = 10 , mA, , V_{GS} = -20 , V$</td>
<td>20</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Gate threshold voltage</td>
<td>$V_{th}$</td>
<td>$V_{DS} = 10 , V, , I_D = 1.0 , mA$</td>
<td>2.0</td>
<td>—</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Drain-source on-resistance</td>
<td>$R_{DS(ON)}$</td>
<td>$V_{GS} = 6 , V, , I_D = 75 , A$</td>
<td>—</td>
<td>0.85</td>
<td>1.3</td>
<td>$m\Omega$</td>
</tr>
<tr>
<td></td>
<td>$V_{GS} = 10 , V, , I_D = 75 , A$</td>
<td>—</td>
<td>0.65</td>
<td>0.79</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.2. Dynamic Characteristics ($T_a = 25 \, ^\circ C$ unless otherwise specified)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Min</th>
<th>Typ.</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input capacitance</td>
<td>$C_{iss}$</td>
<td>$V_{DS} = 10 , V, , V_{GS} = 0 , V, , f = 300 , kHz$</td>
<td>—</td>
<td>6650</td>
<td>—</td>
<td>$pF$</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{rss}$</td>
<td>—</td>
<td>—</td>
<td>490</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Output capacitance</td>
<td>$C_{oss}$</td>
<td>—</td>
<td>—</td>
<td>4300</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Gate resistance</td>
<td>$r_g$</td>
<td>—</td>
<td>—</td>
<td>4.1</td>
<td>—</td>
<td>$\Omega$</td>
</tr>
<tr>
<td>Switching time (rise time)</td>
<td>$t_r$</td>
<td>See Fig. 6.2.1</td>
<td>—</td>
<td>10</td>
<td>—</td>
<td>$ns$</td>
</tr>
<tr>
<td>Switching time (turn-on time)</td>
<td>$t_{on}$</td>
<td>—</td>
<td>—</td>
<td>23</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Switching time (fall time)</td>
<td>$t_f$</td>
<td>—</td>
<td>—</td>
<td>35</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Switching time (turn-off time)</td>
<td>$t_{off}$</td>
<td>—</td>
<td>—</td>
<td>115</td>
<td>—</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 6.2.1  Switching Time Test Circuit

6.3. Gate Charge Characteristics ($T_a = 25 \, ^\circ C$ unless otherwise specified)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Min</th>
<th>Typ.</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total gate charge (gate-source plus gate-drain)</td>
<td>$Q_g$</td>
<td>$V_{DD} = 32 , V, , V_{GS} = 10 , V, , I_D = 150 , A$</td>
<td>—</td>
<td>85</td>
<td>—</td>
<td>$nC$</td>
</tr>
<tr>
<td>Gate-source charge 1</td>
<td>$Q_{gs1}$</td>
<td>—</td>
<td>—</td>
<td>28</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Gate-drain charge</td>
<td>$Q_{gd}$</td>
<td>—</td>
<td>—</td>
<td>14</td>
<td>—</td>
<td></td>
</tr>
</tbody>
</table>

6.4. Source-Drain Characteristics ($T_a = 25 \, ^\circ C$ unless otherwise specified)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Min</th>
<th>Typ.</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse drain current (pulsed)</td>
<td>$I_{DRP}$</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>450</td>
<td>$A$</td>
</tr>
<tr>
<td>Diode forward voltage</td>
<td>$V_{DSF}$</td>
<td>$I_{DR} = 150 , A, , V_{GS} = 0 , V$</td>
<td>—</td>
<td>—</td>
<td>-1.2</td>
<td>$V$</td>
</tr>
</tbody>
</table>

Note 6: Ensure that the channel temperature does not exceed 175 $^\circ C$. 

7. Marking

![Diagram of marking with labels: Part No. (or abbreviation code), Lot No., Pin #1, and K45]

**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 \( V_{DS} - V_{GS} \)

Fig. 8.4 \( V_{DS} - V_{GS} \)

Fig. 8.5 \( V_{DS} - V_{GS} \)

Fig. 8.6 \( V_{DS} - V_{GS} \)
Fig. 8.7  $I_D - V_{GS}$

- Common source $V_{DS} = 10 \text{ V}$
- Pulse test

Fig. 8.8  $R_{DS(ON)} - I_D$

- Common source $T_a = 25 \degree \text{C}$
- Pulse test

Fig. 8.9  $R_{DS(ON)} - T_a$

- Common source
- Pulse test
- $I_D = 37.5, 75, 150 \text{ A}$
- $V_{GS} = 6, 10 \text{ V}$

Fig. 8.10  $I_{DR} - V_{DS}$

- Common source $T_a = 25 \degree \text{C}$
- Pulse test

Fig. 8.11  $V_{BRDSS} - T_a$

- Common source
- Pulse test
- $V_{GS} = 0 \text{ V}$
- $I_D = 10 \text{ mA}$

Fig. 8.12  $V_{th} - T_a$

- Common source
- Pulse test
- $V_{GS} = 10 \text{ V}$
- $I_D = 1.0 \text{ mA}$
Fig. 8.13  Capacitance - V_DS

Fig. 8.14  Dynamic Input/Output Characteristics

Fig. 8.15  E_AS - T_ch (Guaranteed Maximum)

Fig. 8.16  Test Circuit/Waveform

RG = 25 Ω  
V_{DD} = 32 V, L = 9.8 μH  
EAS = \frac{1}{2} \cdot L \cdot IAS^2 \cdot \left( \frac{BVDS - V_D}{BVDS - V_{DD}} \right)
Fig. 8.17  $Z_{th(c-c)} - t_w$
(Guaranteed Maximum)

Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.
Weight: 0.083 g (typ.)

<table>
<thead>
<tr>
<th>Package Name(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOSHIBA: 2-5Q4A</td>
</tr>
<tr>
<td>Nickname: SOP Advance(WF)</td>
</tr>
</tbody>
</table>

Note: Shaded areas are plated. Over 50% of the side of the tip is plated.
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