

TK40E06N1

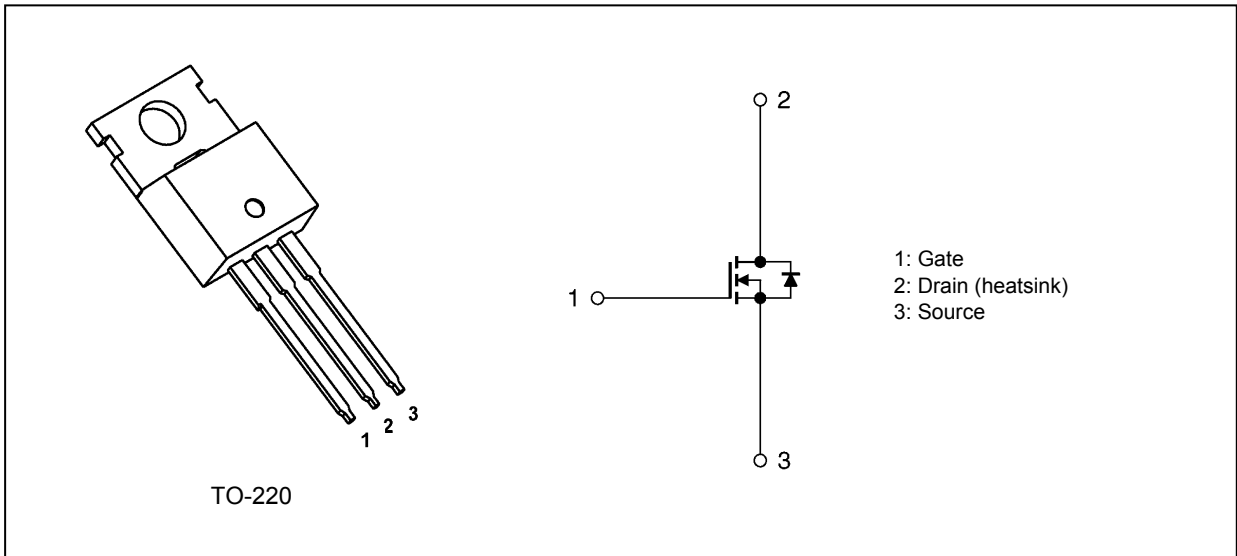
1. Applications

- Switching Voltage Regulators

2. Features

- (1) Low drain-source on-resistance: $R_{DS(ON)} = 8.4 \text{ m}\Omega$ (typ.) ($V_{GS} = 10 \text{ V}$)
- (2) Low leakage current: $I_{DSS} = 10 \text{ }\mu\text{A}$ (max) ($V_{DS} = 60 \text{ V}$)
- (3) Enhancement mode: $V_{th} = 2.0$ to 4.0 V ($V_{DS} = 10 \text{ V}$, $I_D = 0.3 \text{ mA}$)

3. Packaging and Internal Circuit



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

| Characteristics | Symbol | Rating | Unit |
|--|-----------|------------|------------------|
| Drain-source voltage | V_{DSS} | 60 | V |
| Gate-source voltage | V_{GSS} | ± 20 | |
| Drain current (DC) (Silicon limit) (Note 1), (Note 2) | I_D | 60 | A |
| Drain current (DC) (Note 1), (Note 3) | I_D | 40 | |
| Drain current (pulsed) ($t = 1 \text{ ms}$) (Note 1) | I_{DP} | 125 | |
| Power dissipation ($T_c = 25^\circ\text{C}$) | P_D | 67 | W |
| Single-pulse avalanche energy (Note 4) | E_{AS} | 40 | mJ |
| Avalanche current | I_{AR} | 40 | 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

2012-04

5. Thermal Characteristics

| Characteristics | Symbol | Max | Unit |
|---------------------------------------|----------------|------|------|
| Channel-to-case thermal resistance | $R_{th(ch-c)}$ | 1.84 | °C/W |
| Channel-to-ambient thermal resistance | $R_{th(ch-a)}$ | 83.3 | |

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

Note 2: Limited by silicon chip capability.

Note 3: Device mounted with heatsink so that $R_{th(ch-a)}$ becomes 4.16°C/W.

Note 4: $V_{DD} = 48\text{ V}$, $T_{ch} = 25^\circ\text{C}$ (initial), $L = 19.2\ \mu\text{H}$, $I_{AR} = 40\text{ A}$

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

6. Electrical Characteristics

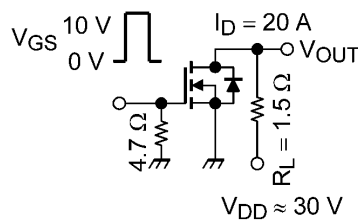
6.1. Static Characteristics ($T_a = 25^\circ\text{C}$ unless otherwise specified)

| Characteristics | Symbol | Test Condition | Min | Typ. | Max | Unit |
|---|---------------|---|-----|------|-----------|------------------|
| Gate leakage current | I_{GSS} | $V_{GS} = \pm 20\text{ V}, V_{DS} = 0\text{ V}$ | — | — | ± 0.1 | μA |
| Drain cut-off current | I_{DSS} | $V_{DS} = 60\text{ V}, V_{GS} = 0\text{ V}$ | — | — | 10 | |
| Drain-source breakdown voltage | $V_{(BR)DSS}$ | $I_D = 10\text{ mA}, V_{GS} = 0\text{ V}$ | 60 | — | — | V |
| Drain-source breakdown voltage (Note 5) | $V_{(BR)DSX}$ | $I_D = 10\text{ mA}, V_{GS} = -20\text{ V}$ | 45 | — | — | |
| Gate threshold voltage | V_{th} | $V_{DS} = 10\text{ V}, I_D = 0.3\text{ mA}$ | 2.0 | — | 4.0 | |
| Drain-source on-resistance | $R_{DS(ON)}$ | $V_{GS} = 10\text{ V}, I_D = 20\text{ A}$ | — | 8.4 | 10.4 | $\text{m}\Omega$ |

Note 5: If a reverse bias is applied between gate and source, this device enters $V_{(BR)DSX}$ mode. Note that the drain-source breakdown voltage is lowered in this mode.

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

| Characteristics | Symbol | Test Condition | Min | Typ. | Max | Unit |
|--------------------------------|-----------|---|-----|------|-----|-------------|
| Input capacitance | C_{iss} | $V_{DS} = 30\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$ | — | 1700 | — | pF |
| Reverse transfer capacitance | C_{rss} | | — | 40 | — | |
| Output capacitance | C_{oss} | | — | 580 | — | |
| Gate resistance | r_g | — | — | 2.0 | — | Ω |
| Switching time (rise time) | t_r | See Figure 6.2.1. | — | 14 | — | ns |
| Switching time (turn-on time) | t_{on} | | — | 30 | — | |
| Switching time (fall time) | t_f | | — | 13 | — | |
| Switching time (turn-off time) | t_{off} | | — | 36 | — | |



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

Fig. 6.2.1 Switching Time Test Circuit

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

| Characteristics | Symbol | Test Condition | Min | Typ. | Max | Unit |
|---|-----------|---|-----|------|-----|-------------|
| Total gate charge (gate-source plus gate-drain) | Q_g | $V_{DD} \approx 48\text{ V}, V_{GS} = 10\text{ V}, I_D = 40\text{ A}$ | — | 23 | — | nC |
| Gate-source charge 1 | Q_{gs1} | | — | 8 | — | |
| Gate-drain charge | Q_{gd} | | — | 7 | — | |
| Gate switch charge | Q_{SW} | | — | 10 | — | |

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

| Characteristics | Symbol | Test Condition | Min | Typ. | Max | Unit |
|---|-----------|---|-----|------|------|------|
| Reverse drain current (DC) (Note 6) | I_{DR} | — | — | — | 40 | A |
| Reverse drain current (pulsed) (Note 6) | I_{DRP} | — | — | — | 125 | |
| Diode forward voltage | V_{DSF} | $I_{DR} = 40\text{ A}, V_{GS} = 0\text{ V}$ | — | — | -1.2 | V |
| Reverse recovery time (Note 7) | t_{rr} | $I_{DR} = 40\text{ A}, V_{GS} = 0\text{ V}$ $-di_{DR}/dt = 100\text{ A}/\mu\text{s}$ | — | 46 | — | ns |
| Reverse recovery charge (Note 7) | Q_{rr} | | — | 62 | — | nC |

Note 6: Ensure that the channel temperature does not exceed 150°C .

Note 7: Ensure that V_{DS} peak does not exceed V_{DSS} .

7. Marking

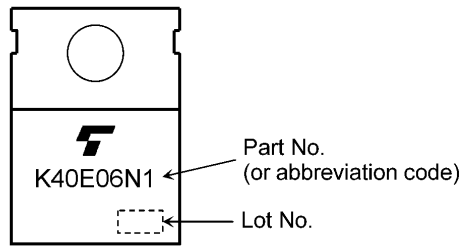


Fig. 7.1 Marking

8. Characteristics Curves (Note)

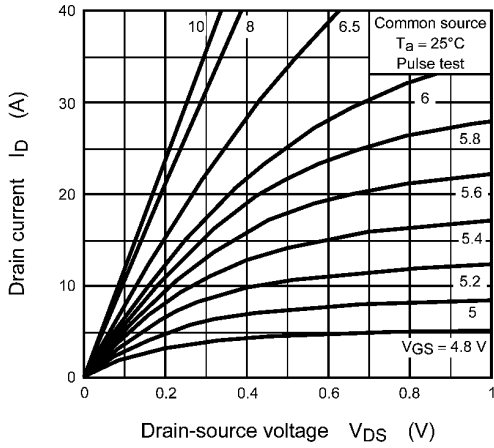


Fig. 8.1 $I_D - V_{DS}$

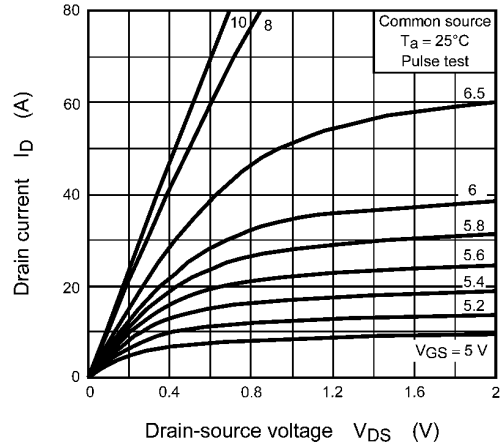


Fig. 8.2 $I_D - V_{DS}$

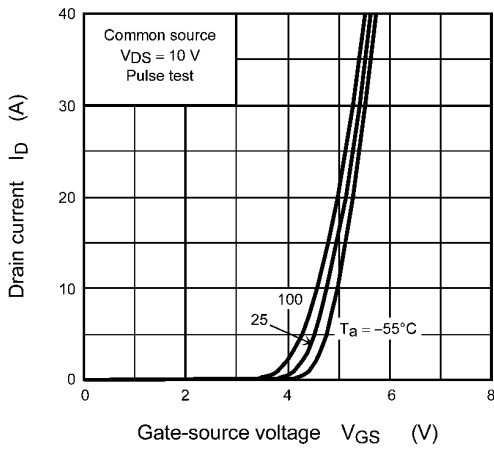


Fig. 8.3 $I_D - V_{GS}$

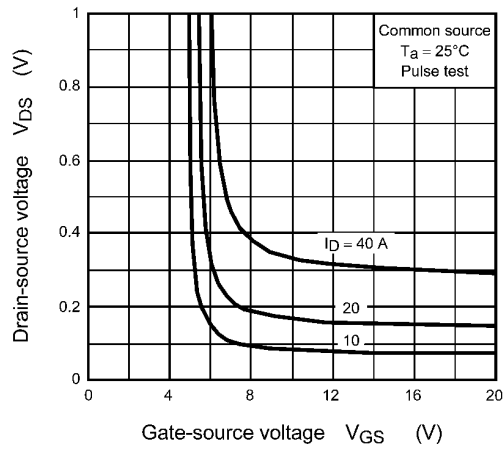


Fig. 8.4 $V_{DS} - V_{GS}$

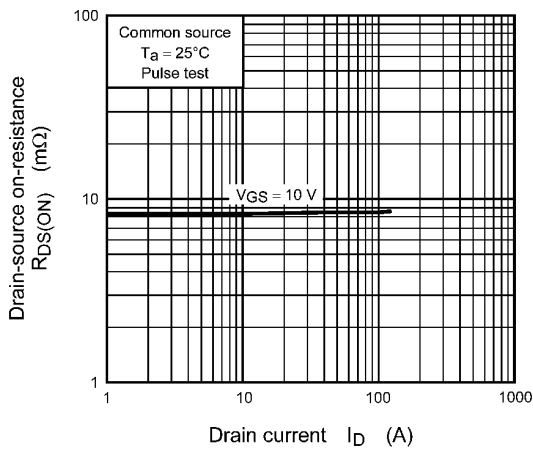


Fig. 8.5 $R_{DS(ON)} - I_D$

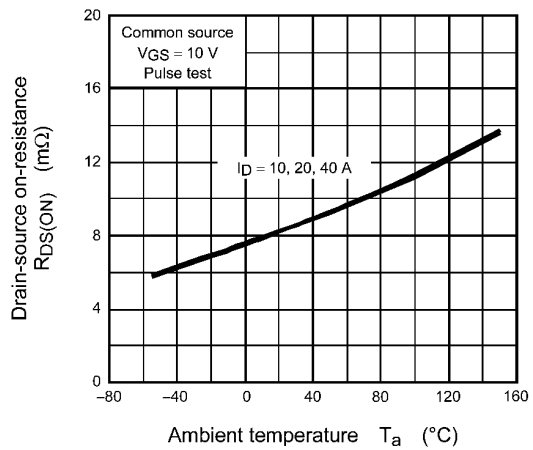


Fig. 8.6 $R_{DS(ON)} - T_a$

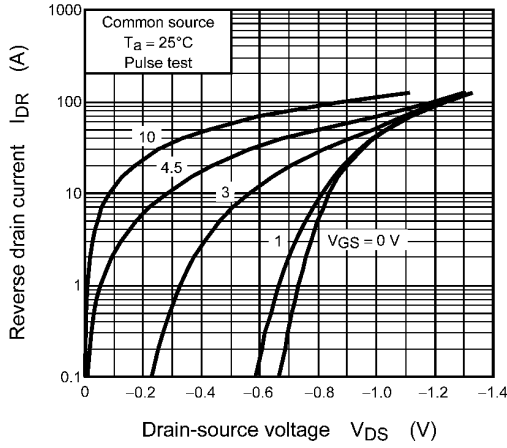


Fig. 8.7 $I_{DR} - V_{DS}$

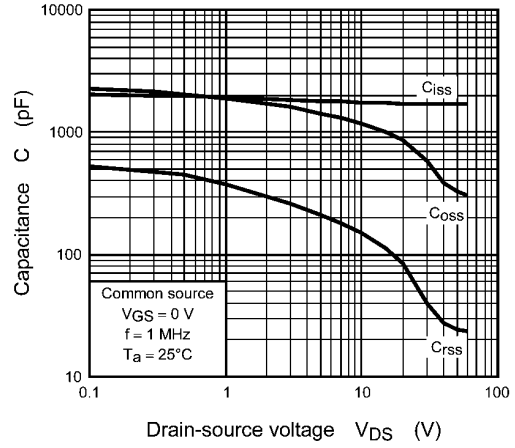


Fig. 8.8 Capacitance - V_{DS}

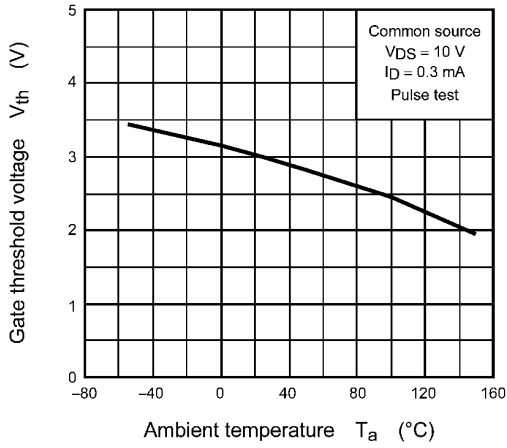


Fig. 8.9 $V_{th} - T_a$

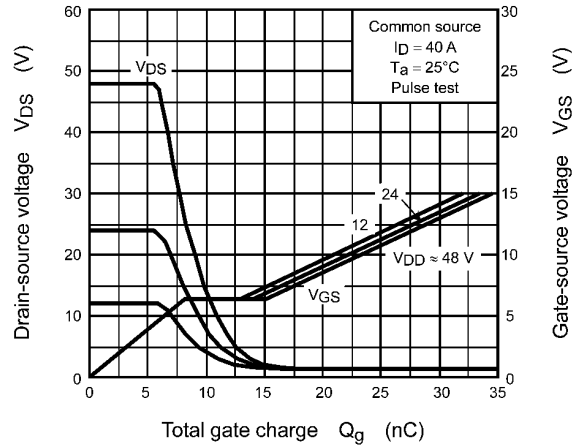
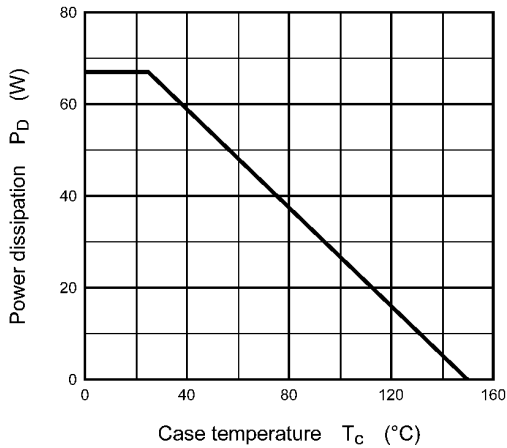


Fig. 8.10 Dynamic Input/Output Characteristics



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

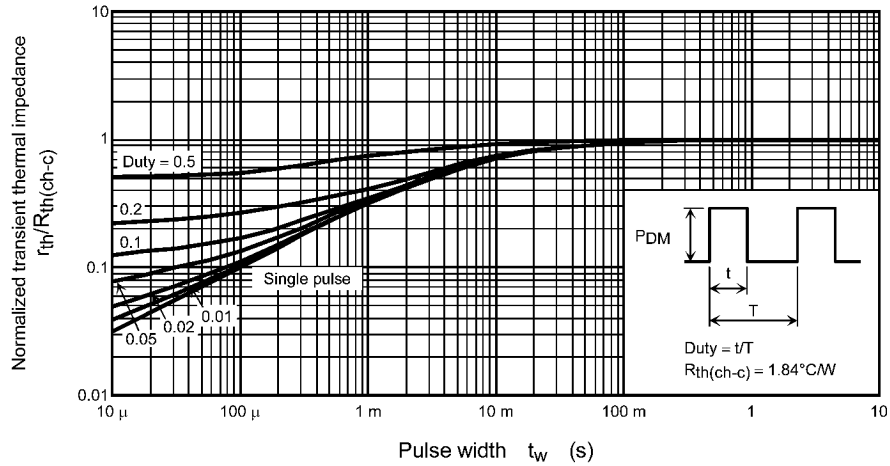


Fig. 8.12 $r_{th}/R_{th(ch-c)} - t_w$
(Guaranteed Maximum)

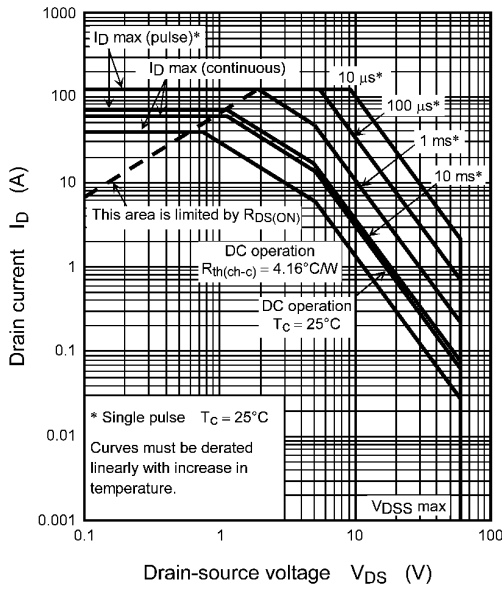


Fig. 8.13 Safe Operating Area
(Guaranteed Maximum)

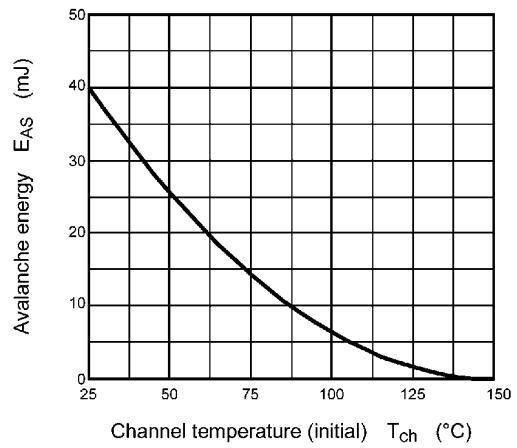
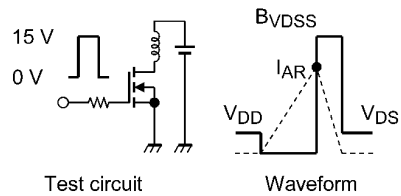


Fig. 8.14 $E_{AS} - T_{ch}$
(Guaranteed Maximum)



$$V_{DD} = 48 \text{ V}, I_{AR} = 40 \text{ A} \quad E_{AS} = \frac{1}{2} \cdot L \cdot I_{AR}^2 \cdot \left(\frac{B_{VDSS}}{B_{VDSS} - V_{DD}} \right)$$

Fig. 8.15 Test Circuit/Waveform

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

Package Dimensions

Unit: mm



Weight: 1.93 g (typ.)

| Package Name(s) |
|------------------|
| TOSHIBA: 2-10X1A |
| Nickname: TO-220 |

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