

TK40E06N1

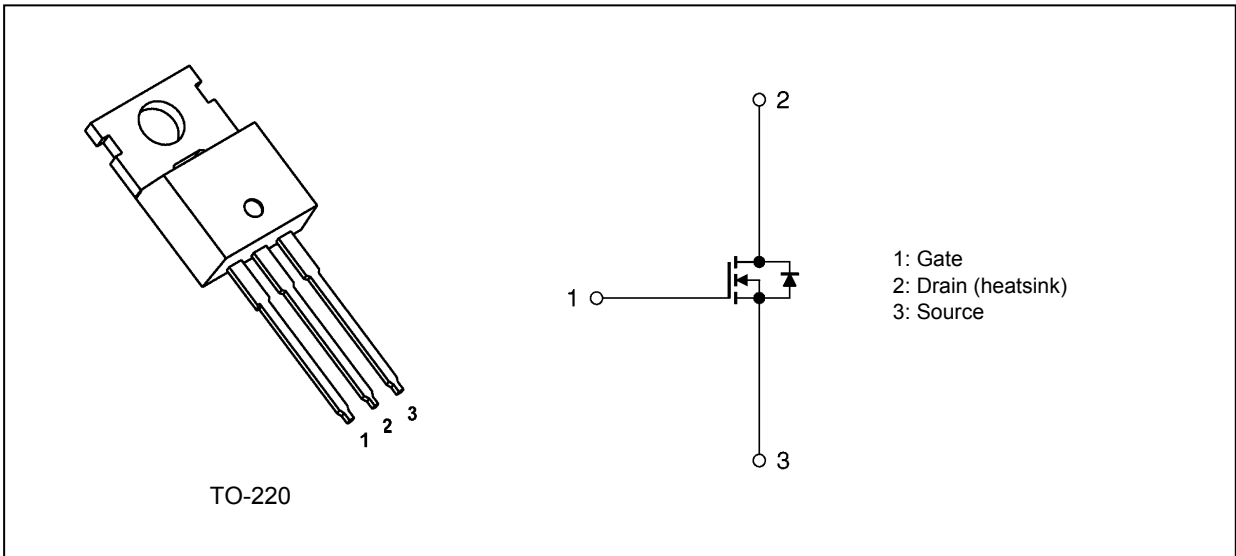
1. Applications

- 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: $V_{th} = 2.0 \text{ to } 4.0 \text{ V}$ ($V_{DS} = 10 \text{ V}$, $I_D = 0.3 \text{ mA}$)

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

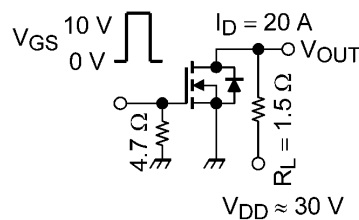
6.1. Static Characteristics ($T_a = 25^\circ\text{C}$ unless otherwise specified)

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

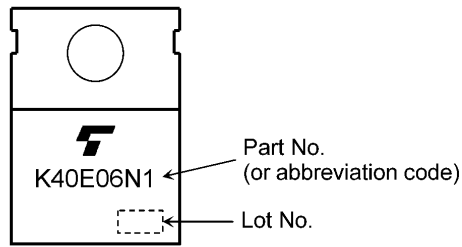


Fig. 7.1 Marking

8. Characteristics Curves (Note)

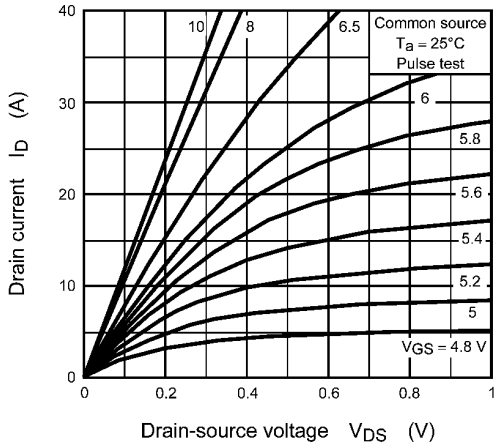


Fig. 8.1 $I_D - V_{DS}$

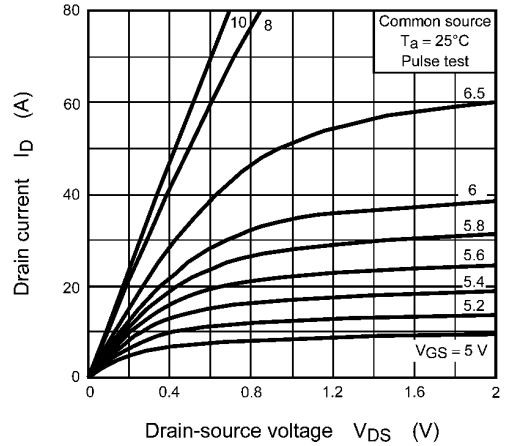


Fig. 8.2 $I_D - V_{DS}$

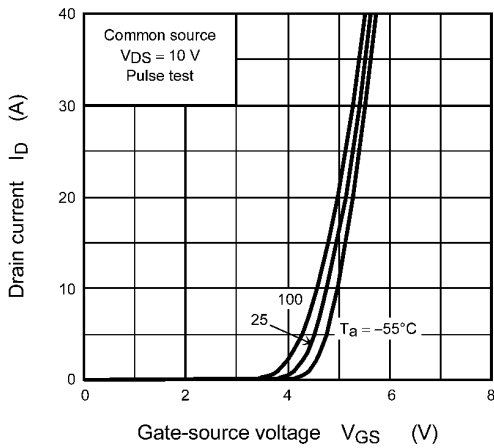


Fig. 8.3 $I_D - V_{GS}$

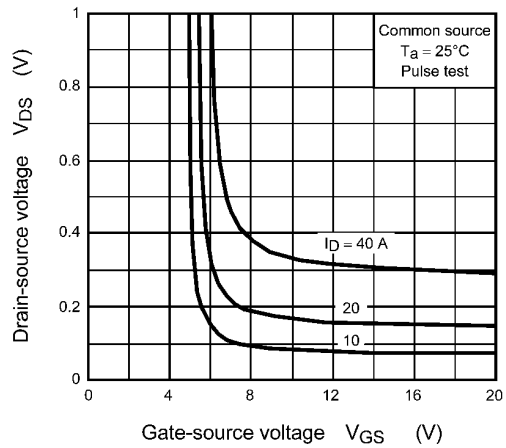


Fig. 8.4 $V_{DS} - V_{GS}$

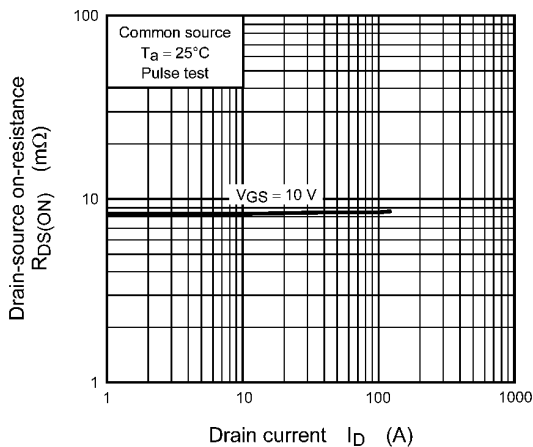


Fig. 8.5 $R_{DS(ON)} - I_D$

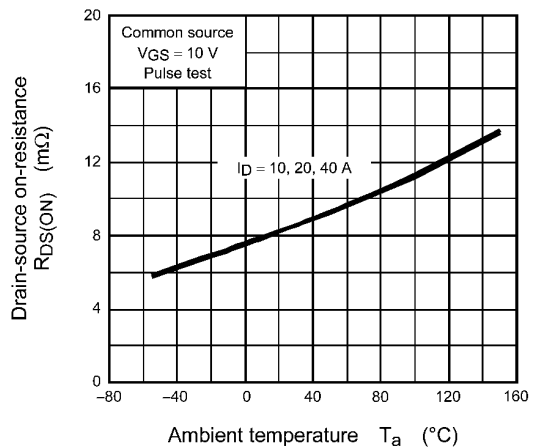


Fig. 8.6 $R_{DS(ON)} - T_a$

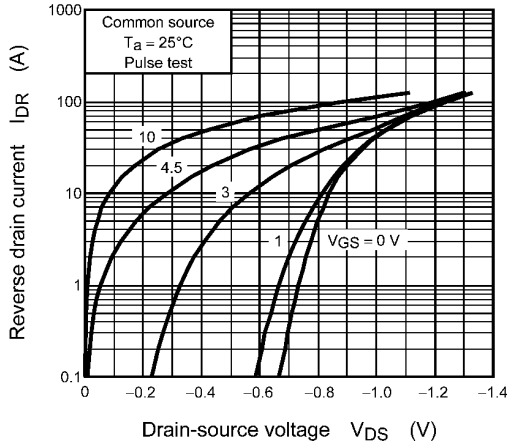


Fig. 8.7 $I_{DR} - V_{DS}$

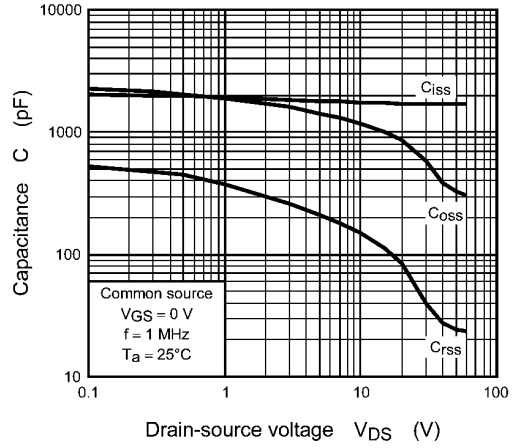


Fig. 8.8 Capacitance - V_{DS}

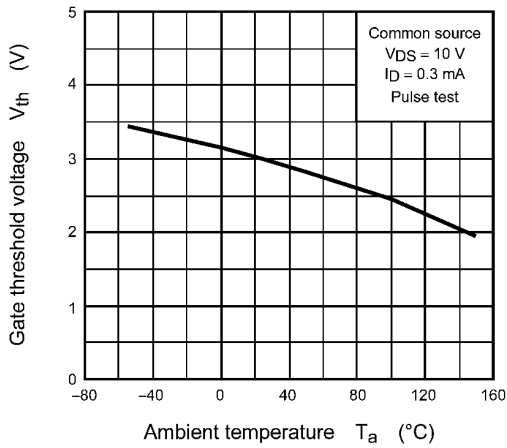


Fig. 8.9 $V_{th} - T_a$

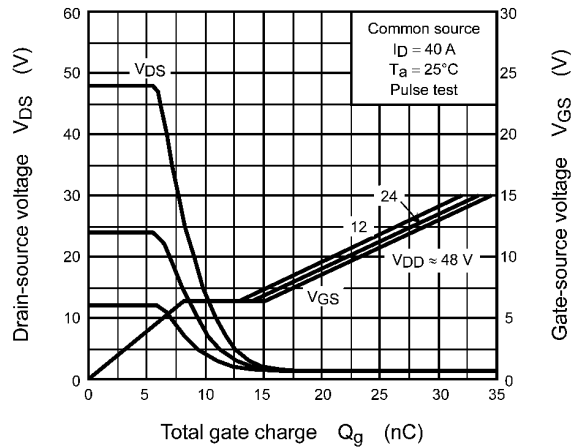
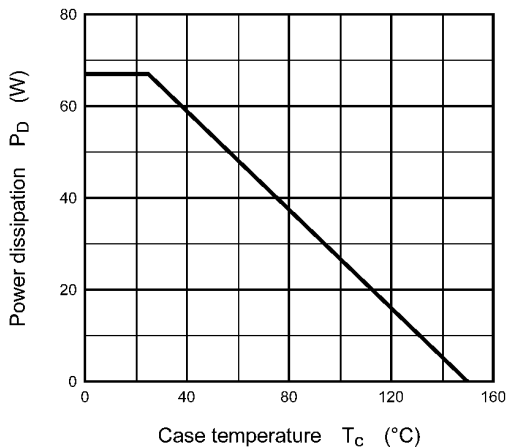


Fig. 8.10 Dynamic Input/Output Characteristics



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

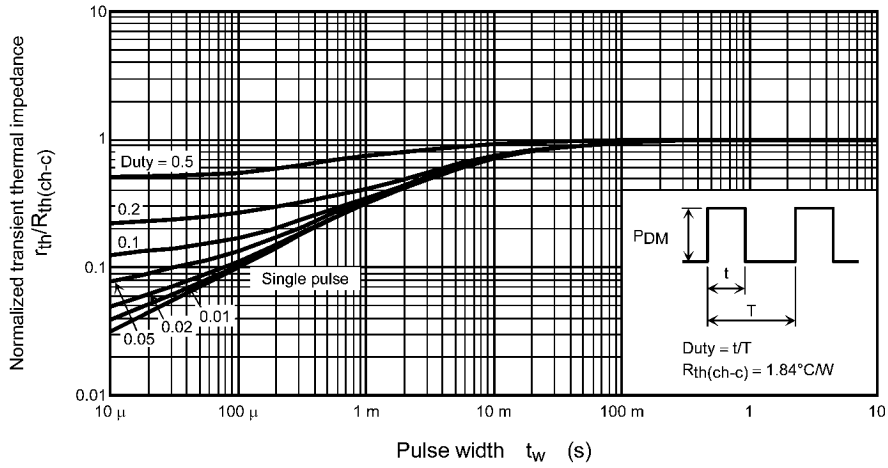


Fig. 8.12 $r_{th}/R_{th(ch-c)} - t_w$
(Guaranteed Maximum)

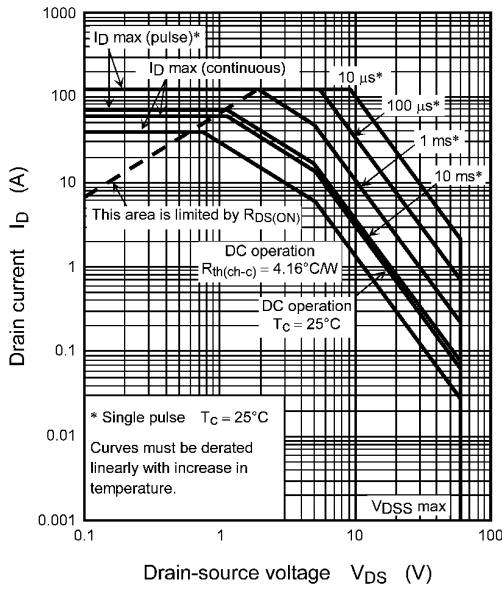


Fig. 8.13 Safe Operating Area
(Guaranteed Maximum)

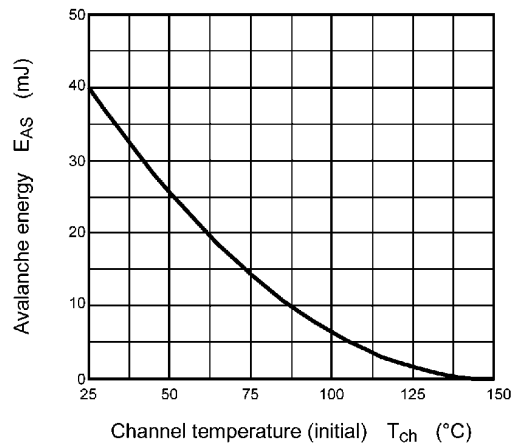
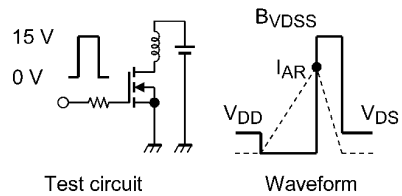


Fig. 8.14 $E_{AS} - T_{ch}$
(Guaranteed Maximum)



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

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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