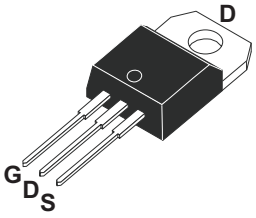
# N-Channel Power MOSFET
# (10A, 600Volts)

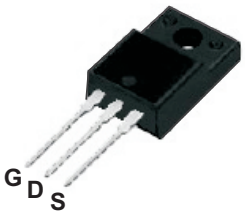
## DESCRIPTION

The Nell **10N60** is a three-terminal silicon device with current conduction capability of 10A, fast switching speed, low on-state resistance, breakdown voltage rating of 600V, and max. threshold voltage of 4 volts.

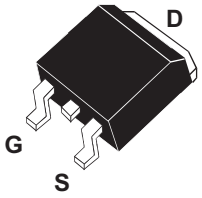
They are designed for use in applications such as switched mode power supplies, DC to DC converters, **PWM** motor controls, bridge circuits and general purpose switching applications.




TO-220AB
(10N60A)




TO-220F
(10N60AF)

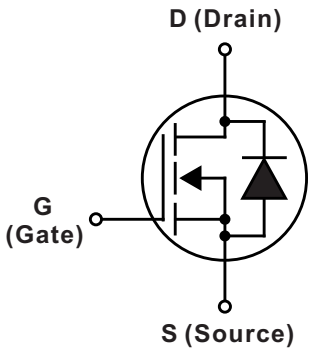



TO-263($D^2$PAK)
(10N60H)

## FEATURES

- $R_{DS(ON)}$ = 0.8Ω@$V_{GS}$ = 10V
- Ultra low gate charge(57nC max.)
- Low reverse transfer capacitance ($C_{RSS}$ = 18pF typical)
- Fast switching capability
- 100% avalanche energy specified
- Improved dv/dt capability
- 150°C operation temperature

| PRODUCT SUMMARY | |
|---|---|
| $I_D$ (A) | 10 |
| $V_{DSS}$ (V) | 600 |
| $R_{DS(ON)}$ (Ω) | 0.8 @ $V_{GS}$ = 10V |
| $Q_G$(nC) max. | 57 |

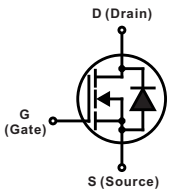


| ABSOLUTE MAXIMUM RATINGS ($T_C$ = 25°C unless otherwise specified) | | | | | |
|---|---|---|---|---|---|
| SYMBOL | PARAMETER | TEST CONDITIONS | | VALUE | UNIT |
| $V_{DSS}$ | Drain to Source voltage | $T_J$=25°C to 150°C | | 600 | V |
| $V_{DGR}$ | Drain to Gate voltage | $R_{GS}$=20KΩ | | 600 | |
| $V_{GS}$ | Gate to Source voltage | | | ±30 | |
| $I_D$ | Continuous Drain Current | $T_C$=25°C | | 10 | A |
| | | $T_C$=100°C | | 6.2 | |
| $I_{DM}$ | Pulsed Drain current(Note 1) | | | 40 | |
| $I_{AR}$ | Avalanche current(Note 1) | | | 10 | |
| $E_{AR}$ | Repetitive avalanche energy(Note 1) | $I_{AR}$=10A, $R_{GS}$=50Ω, $V_{GS}$=10V | | 15.6 | mJ |
| $E_{AS}$ | Single pulse avalanche energy (Note 2) | $I_{AS}$=10A, L = 14.2mH | | 700 | |
| dv/dt | Peak diode recovery dv/dt(Note 3) | | | 4.5 | V /ns |
| $P_D$ | Total power dissipation | $T_C$=25°C | TO-220AB/ TO-263 | 156 | W |
| | | | TO-220F | 50 | |
| $T_J$ | Operation junction temperature | | | -55 to 150 | °C |
| $T_{STG}$ | Storage temperature | | | -55 to 150 | |
| $T_L$ | Maximum soldering temperature, for 10 seconds | 1.6mm from case | | 300 | |
| | Mounting torque, #6-32 or M3 screw | | | 10 (1.1) | lbf·in (N·m) |

Note: 1.Repetitive rating: pulse width limited by junction temperature.
2.$I_{AS}$ = 10A, $V_{DD}$ = 50V, L = 14.2mH, $R_{GS}$ = 25Ω, starting $T_J$=25°C.
3.$I_{SD}$ ≤ 10A, di/dt ≤ 200A/μs, $V_{DD}$ ≤ $V_{(BR)DSS}$, starting $T_J$=25°C.

| THERMAL RESISTANCE | | | | | | |
|---|---|---|---|---|---|---|
| SYMBOL | PARAMETER | | Min. | Typ. | Max. | UNIT |
| $R_{th(j-c)}$ | Thermal resistance, junction to case | TO-220AB/ TO-263 | | | 0.8 | °C/W |
| | | TO-220F | | | 2.5 | |
| $R_{th(j-a)}$ | Thermal resistance, junction to ambient | TO-220AB/TO-263 | | | 62.5 | |
| | | TO-220F | | | 62.5 | |

| ELECTRICAL CHARACTERISTICS ($T_C$ = 25°C unless otherwise specified) | | | | | | |
|---|---|---|---|---|---|---|
| SYMBOL | PARAMETER | TEST CONDITIONS | Min. | Typ. | Max. | UNIT |
| $V_{(BR)DSS}$ | Drain to source breakdown voltage | $I_D$ = 250μA, $V_{GS}$ = 0V | 600 | | | V |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown voltage temperature coefficient | $I_D$ = 250μA, $V_{DS}$ = $V_{GS}$ | | 0.7 | | V/°C |
| $I_{DSS}$ | Drain to source leakage current | $V_{DS}$=600V, $V_{GS}$=0V, $T_C$ = 25°C | | | 10 | μA |
| | | $V_{DS}$=480V, $V_{GS}$=0V, $T_C$=125°C | | | 100 | |
| $I_{GSS}$ | Gate to source forward leakage current | $V_{GS}$ = 30V, $V_{DS}$ = 0V | | | 100 | nA |
| | Gate to source reverse leakage current | $V_{GS}$ = -30V, $V_{DS}$ = 0V | | | -100 | |
| $R_{DS(ON)}$ | Static drain to source on-state resistance | $I_D$ = 5A, $V_{GS}$ = 10V | | 0.72 | 0.80 | Ω |
| $V_{GS(TH)}$ | Gate threshold voltage | $V_{GS}$=$V_{DS}$, $I_D$=250μA | 2.0 | | 4.0 | V |
| $C_{ISS}$ | Input capacitance | $V_{DS}$ = 25V, $V_{GS}$ = 0V, f =1MHz | | 1570 | 2040 | pF |
| $C_{OSS}$ | Output capacitance | | | 166 | 215 | |
| $C_{RSS}$ | Reverse transfer capacitance | | | 18 | 24 | |
| $t_{d(ON)}$ | Turn-on delay time | $V_{DD}$ = 300V, $V_{GS}$ = 10V, $I_D$ = 10A $R_{GS}$ = 25Ω(Note 1, 2) | | 23 | 55 | ns |
| $t_r$ | Rise time | | | 69 | 150 | |
| $t_{d(OFF)}$ | Turn-off delay time | | | 144 | 300 | |
| $t_f$ | Fall time | | | 77 | 165 | |
| $Q_G$ | Total gate charge | $V_{DD}$ = 480V, $V_{GS}$ = 10V, $I_D$ = 10A (Note 1, 2) | | 44 | 57 | nC |
| $Q_{GS}$ | Gate to source charge | | | 6.7 | | |
| $Q_{GD}$ | Gate to drain charge (Miller charge) | | | 18.5 | | |

| SOURCE TO DRAIN DIODE RATINGS AND CHARACTERISTICS ($T_C$ = 25°C unless otherwise specified) | | | | | | |
|---|---|---|---|---|---|---|
| SYMBOL | PARAMETER | TEST CONDITIONS | Min. | Typ. | Max. | UNIT |
| $V_{SD}$ | Diode forward voltage | $I_{SD}$ = 10A, $V_{GS}$ = 0V | | | 1.4 | V |
| Is ($I_{SD}$) | Continuous source to drain current | Integral reverse P-N junction diode in the MOSFET | | | 10 | A |
| $I_{SM}$ | Pulsed source current |   | | | 40 | |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 10A, $V_{GS}$ = 0V, $dI_F/dt$ = 100A/μs | | 420 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | | 4.2 | | μC |

Note: 1. Pulse test: Pulse width ≤ 300μs, duty cycle ≤ 2%.

2. Essentially independent of operating temperature.

## ORDERING INFORMATION SCHEME

**10 N 60 A**

**Current rating, $I_D$**
10 = 10A

**MOSFET series**
N = N-Channel

**Voltage rating, $V_{DS}$**
60 = 600V

**Package type**
A = TO-220AB
AF = TO-220F
H = TO-263P($D^2$PAK)

## ■ TEST CIRCUITS AND WAVEFORMS

**Fig.1A Peak diode recovery dv/dt test circuit**

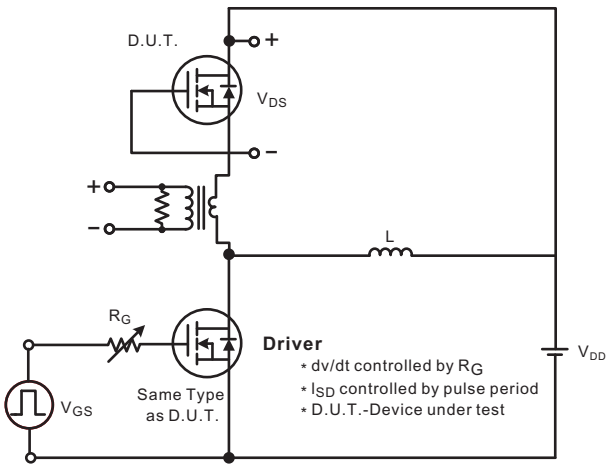
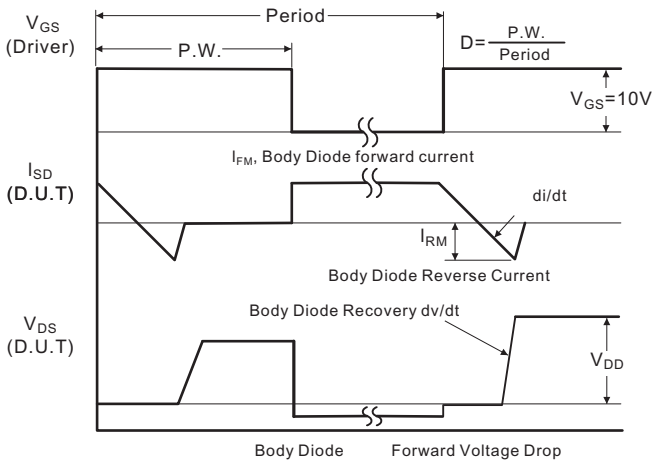



**Fig.1B Peak diode recovery dv/dt waverforms**



## ■ TEST CIRCUITS AND WAVEFORMS (Cont.)

**Fig.2A Switching test circuit**

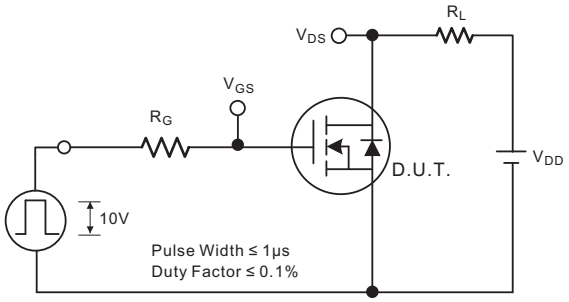



**Fig.2B Switching Waveforms**

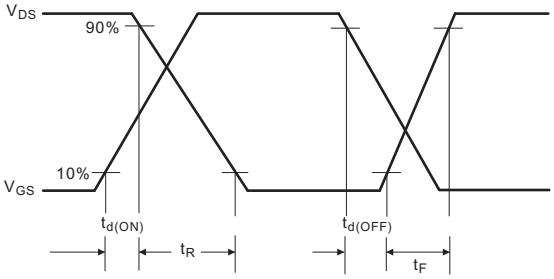



**Fig.3A Gate charge test circuit**

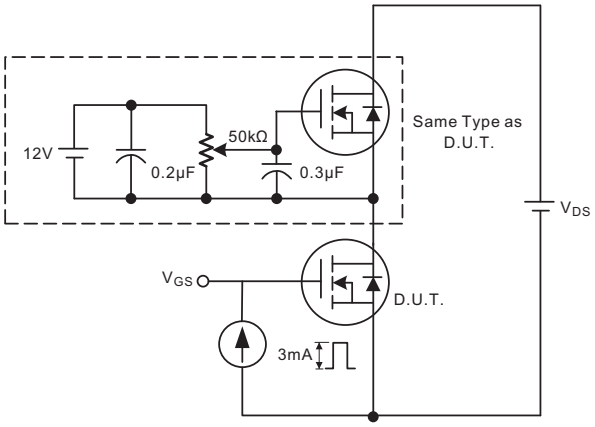



**Fig.3B Gate charge waveform**

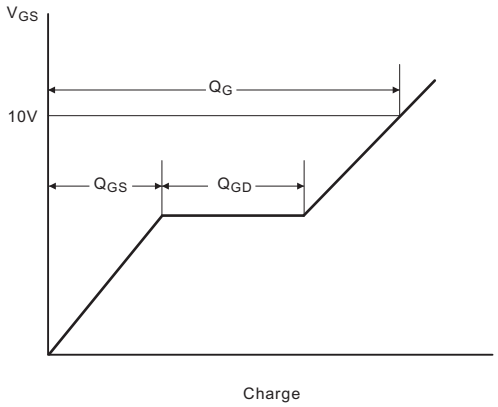



**Fig.4A Unclamped Inductive switching test circuit**

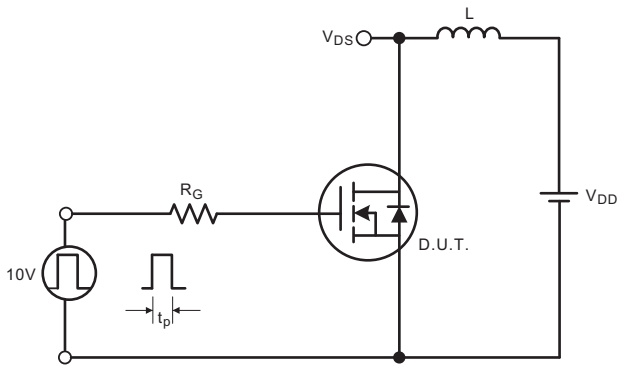
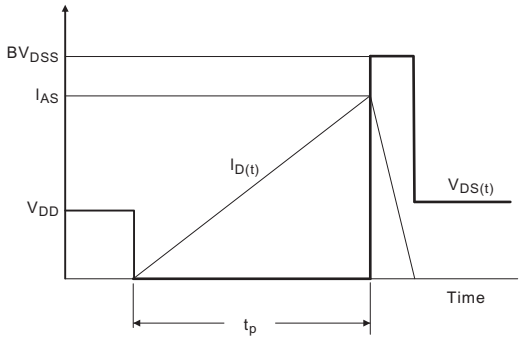



**Fig.4B Unclamped Inductive switching waveforms**



## ■ TYPICAL CHARACTERISTICS

**Fig.1 On-State characteristics**

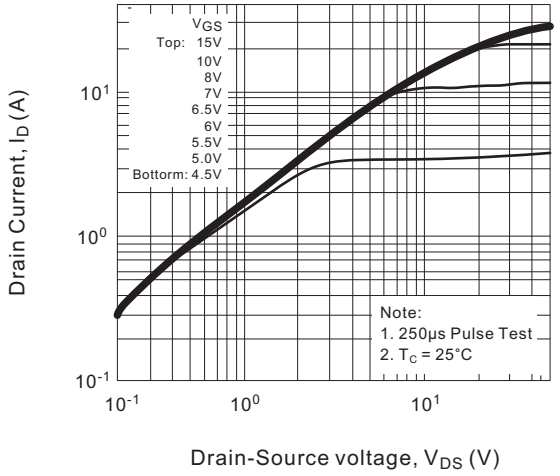



**Fig.2 Transfer characteristics**

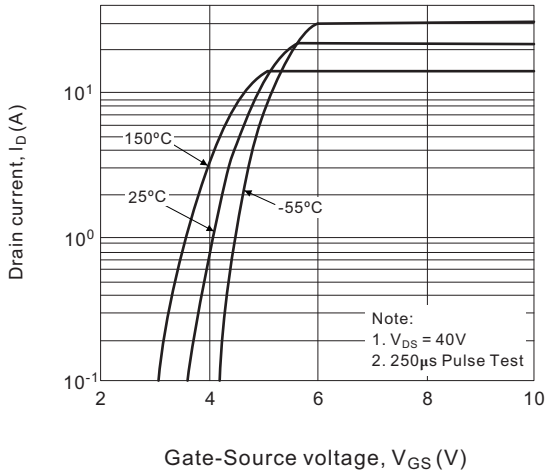



**Fig.3 On-Resistance variation vs. drain current and gate voltage**

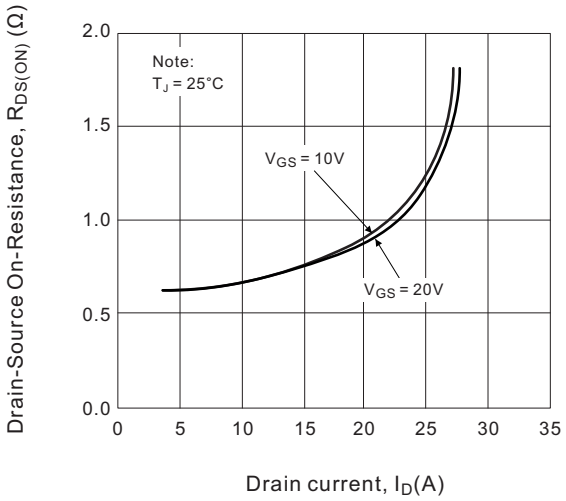



**Fig.4 Body diode forward voltage variation with Source current and Temperatue**

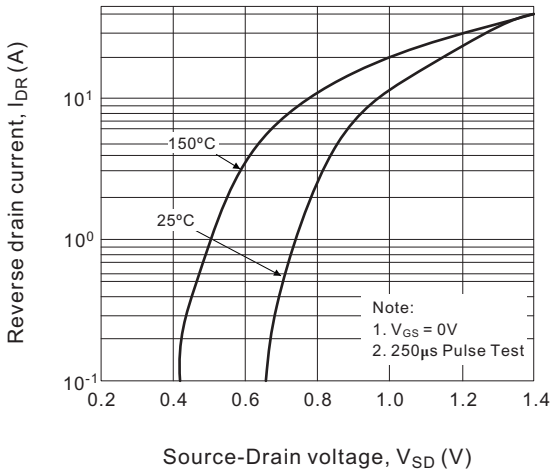



**Fig.5 Capacitance characteristics**

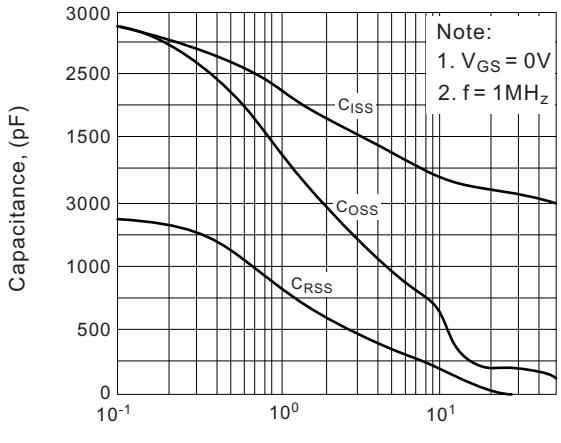



**Fig.6 Gate charge characteristics**

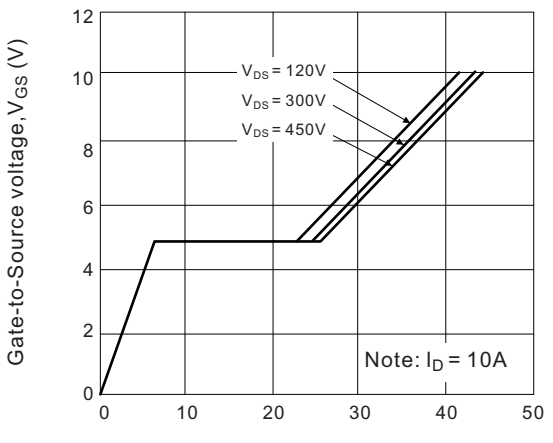


**Fig.7 Breakdown voltage variation vs. Temperature**

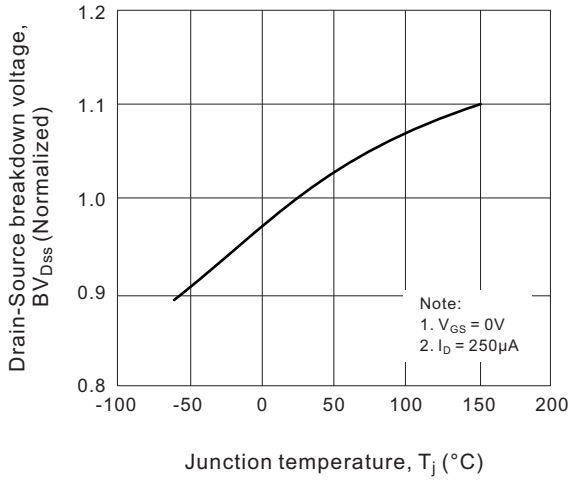



**Fig.8 On-Resistance variation vs. Temperature**

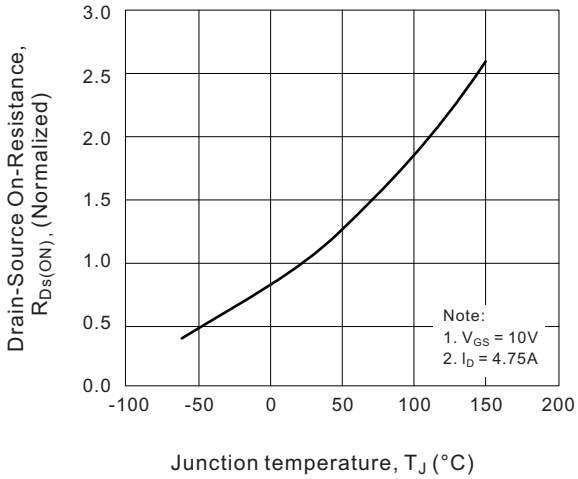



**Fig.9 Maximum safe operating area**

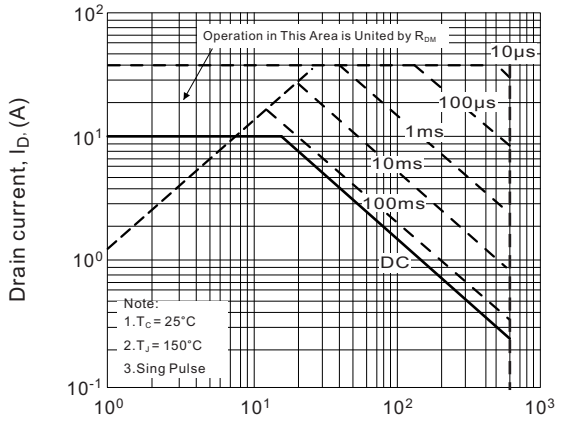



**Fig.10 Maximum drain current vs. Case temperature**

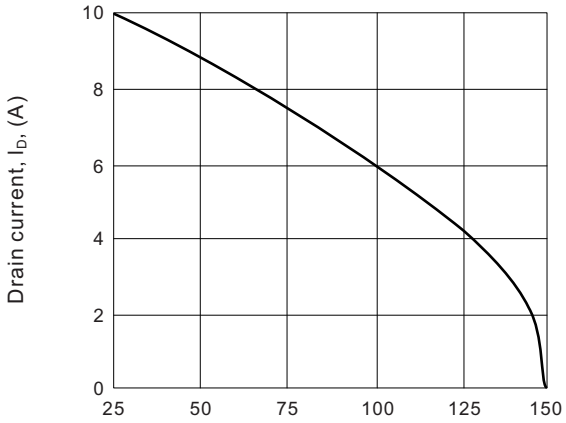
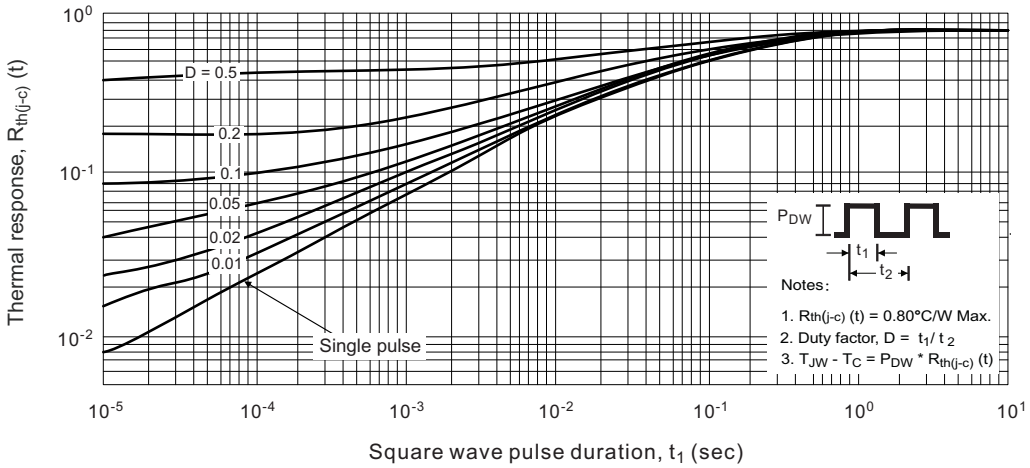
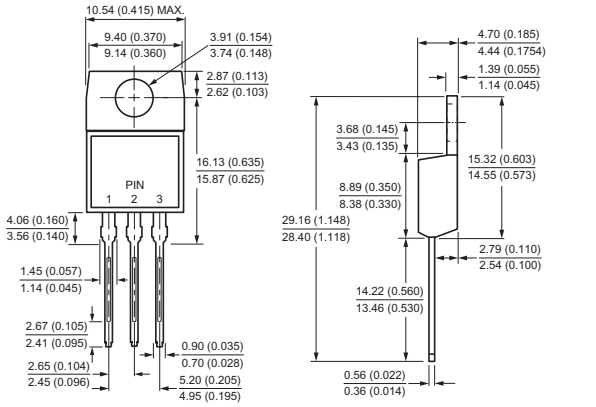


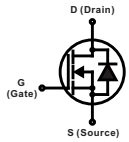

**Fig.11 Transient thermal response curve**



## Case Style

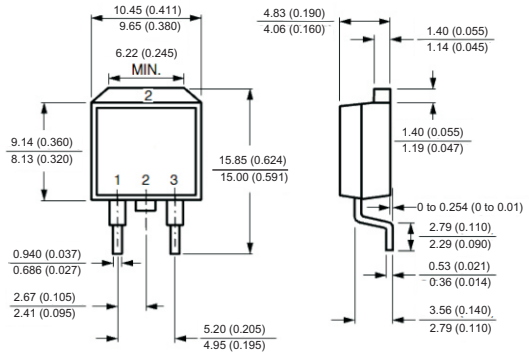
**TO-220AB**

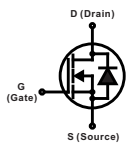



All dimensions in millimeters(inches)

**TO-263($D^2$PAK)**

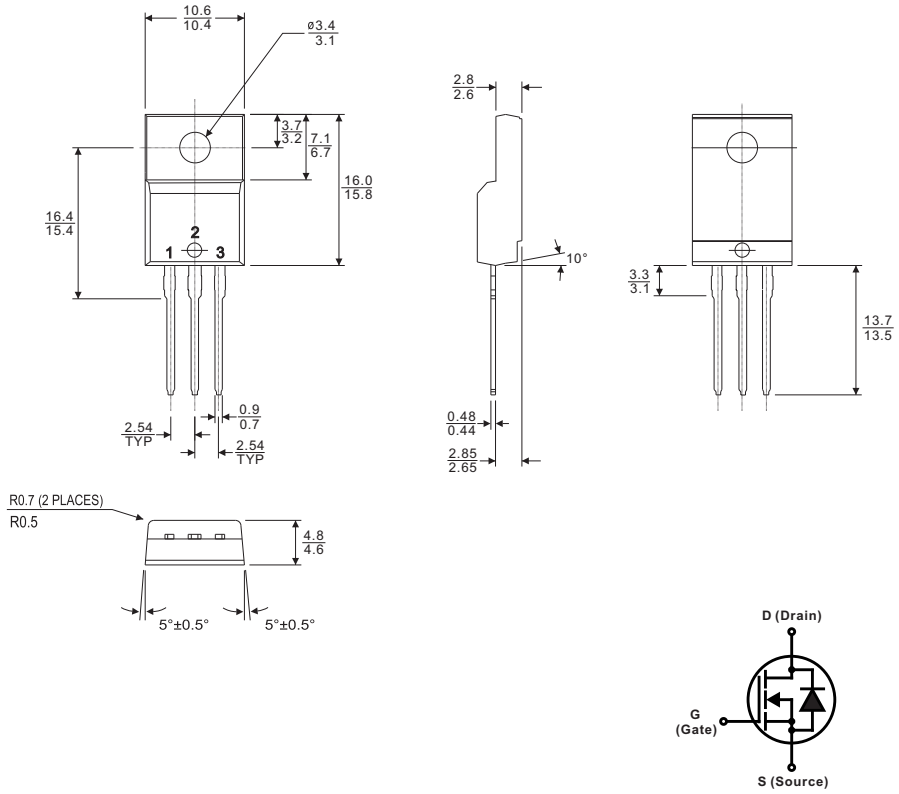



All dimensions in millimeters(inches)

## Case Style

**TO-220F**




All dimensions in millimeters