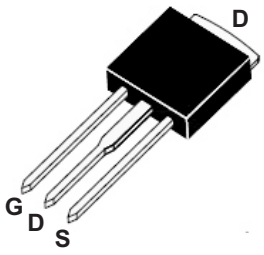
N-Channel Power MOSFET
(4A, 600Volts)

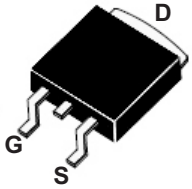
DESCRIPTION

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

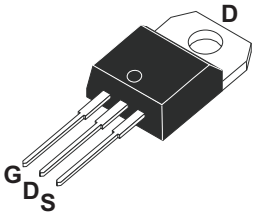
They are designed for use in applications such as switched mode power supplies, DC to DC converters, **PWM** motor controls, bridge circuits and general purpose switching applications.



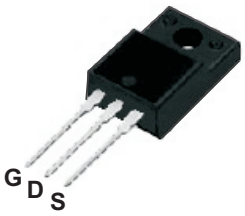
TO-251 **(I-PAK)**
(4N60F)



TO-252 **(D-PAK)**
(4N60G)



TO-220AB
(4N60A)

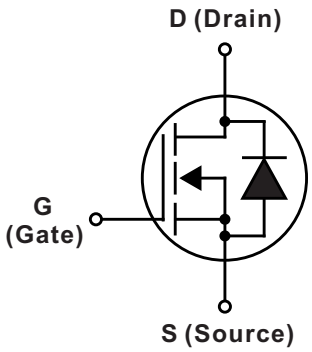


TO-220F
(4N60AF)

FEATURES

- $R_{DS(ON)}$ = 2.5Ω@V_{GS} = 10V
- Ultra low gate charge(20nC max.)
- Low reverse transfer capacitance (C_{RSS} = 8pF typical)
- Fast switching capability
- 100% avalanche energy specified
- Improved dv/dt capability
- 150°C operation temperature

PRODUCT SUMMARY	
I_D (A)	4
V_{DSS} (V)	600
$R_{DS(ON)}$ (Ω)	2.5 @ V_{GS} = 10V
Q_G(nC) max.	20

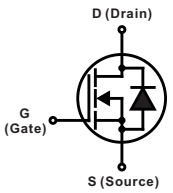


ABSOLUTE MAXIMUM RATINGS (T_C = 25°C unless otherwise specified)					
SYMBOL	**PARAMETER**	**TEST CONDITIONS**		**VALUE**	**UNIT**
V_{DSS}	Drain to Source voltage	T_J=25°C to 150°C		600	V
V_{DGR}	Drain to Gate voltage	R_{GS}=20KΩ		600	
V_{GS}	Gate to Source voltage			±30	
I_D	Continous Drain Current	T_C=25°C		4	A
		T_C=100°C		2.48	
I_{DM}	Pulsed Drain current(Note 1)			16	
I_{AR}	Avalanche current(Note 1)			4	
E_{AR}	Repetitive avalanche energy(Note 1)	I_{AR}=4A, R_{GS}=50Ω, V_{GS}=10V		10.6	mJ
E_{AS}	Single pulse avalanche energy (Note 2)	I_{AS}=4A, L = 30mH		260	
dv/dt	Peak diode recovery dv/dt(Note 3)			4.5	V /ns
P_D	Total power dissipation (Derate above 25°C)	T_C=25°C	TO-251/ TO-252	50 (0.39)	W(W/°C)
			TO-220AB	100 (0.8)	
			TO-220F	36 (0.26)	
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} = 4A, V_{DD} = 50V, L = 30mH, R_{GS} = 25Ω, starting T_J=25°C.
3.I_{SD} ≤ 4A, 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-251/ TO-252			2.5	°C/W
		TO-220AB			1.2	
		TO-220F			3.5	
$R_{th(j-a)}$	Thermal resistance, junction to ambient	TO-251/TO-252			85	
		TO-220AB			62.5	
		TO-220F			62.5	

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise specified)						
SYMBOL	PARAMETER	TEST CONDITIONS	Min.	Typ.	Max.	UNIT
◎ OFF CHARACTERISTICS						
$V_{(BR)DSS}$	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}		0.6		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	
◎ ON CHARACTERISTICS						
$R_{DS(ON)}$	Static drain to source on-state resistance	I_D = 2A, V_{GS} = 10V		2.2	2.5	Ω
$V_{GS(TH)}$	Gate threshold voltage	V_{GS}=V_{DS}, I_D=250μA	2.0		4.0	V
g_{FS}	Forward transconductance	V_{DS}=40V, I_D=2A		4.7		S
◎ DYNAMIC CHARACTERISTICS						
C_{ISS}	Input capacitance	V_{DS} = 25V, V_{GS} = 0V, f =1MHz		520	670	pF
C_{OSS}	Output capacitance			70	90	
C_{RSS}	Reverse transfer capacitance			8.0	11	
◎ SWITCHING CHARACTERISTICS						
$t_{d(ON)}$	Turn-on delay time	V_{DD} = 300V, V_{GS} = 10V, I_D = 4A, R_{GS} = 25Ω(Note 1, 2)		13	35	ns
t_r	Rise time			45	100	
$t_{d(OFF)}$	Turn-off delay time			25	60	
t_f	Fall time			35	80	
Q_G	Total gate charge	V_{DD} = 480V, V_{GS} = 10V, I_D = 4A (Note 1, 2)		15	20	nC
Q_{GS}	Gate to source charge			3.5		
Q_{GD}	Gate to drain charge (Miller charge)			7.0		

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} = 4A, V_{GS} = 0V			1.4	V
Is (I_{SD})	Continous source to drain current	Integral reverse P-N junction diode in the MOSFET			4	A
I_{SM}	Pulsed source current				16	
t_{rr}	Reverse recovery time	I_{SD} = 4A, V_{GS} = 0V, dI_F/dt = 100A/μs		250		ns
Q_{rr}	Reverse recovery charge			1.5		μC

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

2. Essentially independent of operating temperature.

ORDERING INFORMATION SCHEME

4 N 60 A

Current rating, I_D
4 = 4A

MOSFET series
N = N-Channel

Voltage rating, V_{DS}
60 = 600V

Package type
A = TO-220AB
AF = TO-220F
F = TO-251(I-PAK)
G = TO-252(D-PAK)

■ TEST CIRCUITS AND WAVEFORMS

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

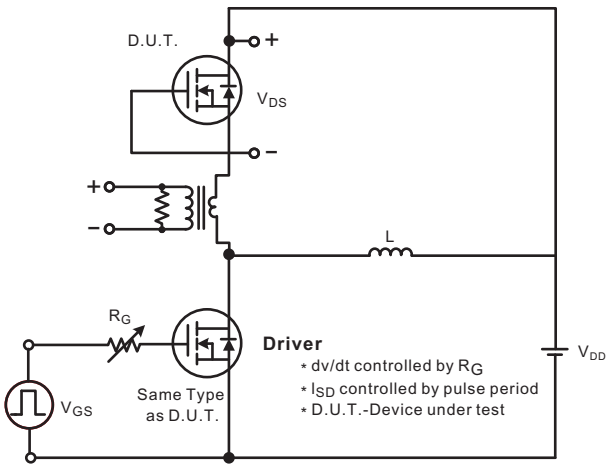
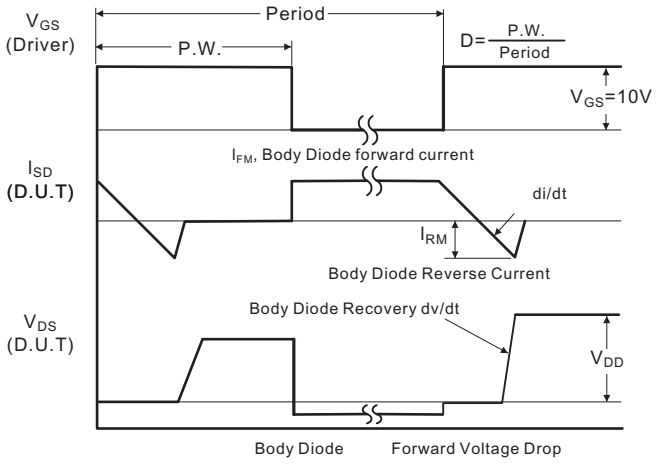


Fig.1B Peak diode recovery dv/dt waveforms



■ TEST CIRCUITS AND WAVEFORMS(Cont.)

Fig.2A Switching test circuit

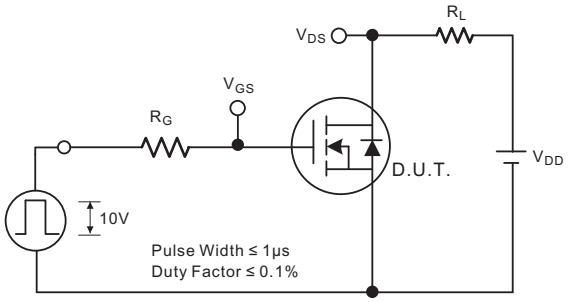


Fig.2B Switching Waveforms

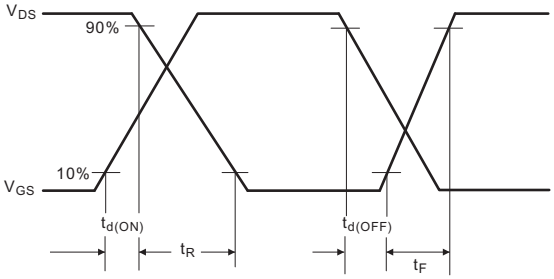


Fig.3A Gate charge test circuit

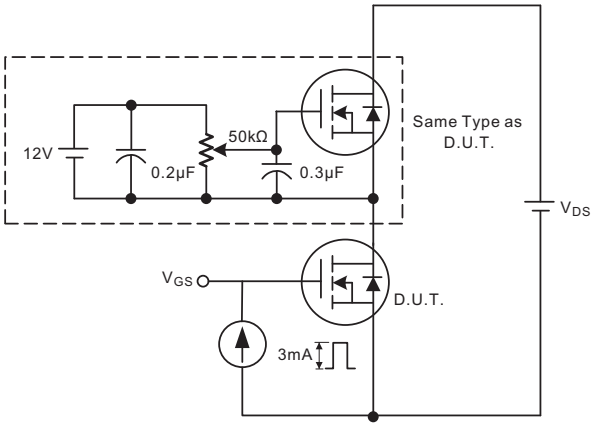


Fig.3B Gate charge waveform

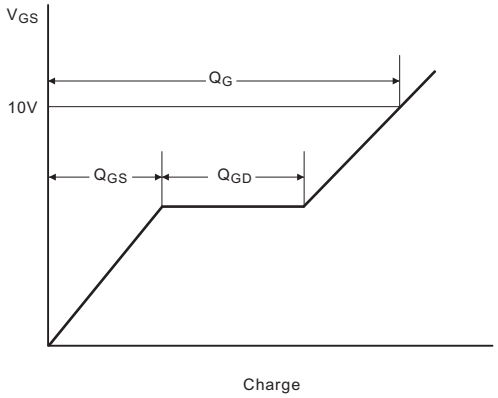


Fig.4A Unclamped Inductive switching test circuit

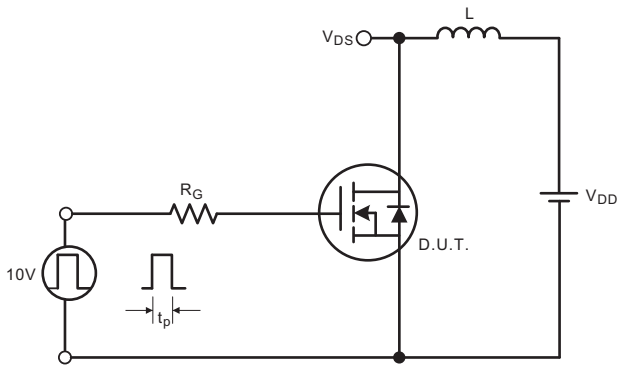
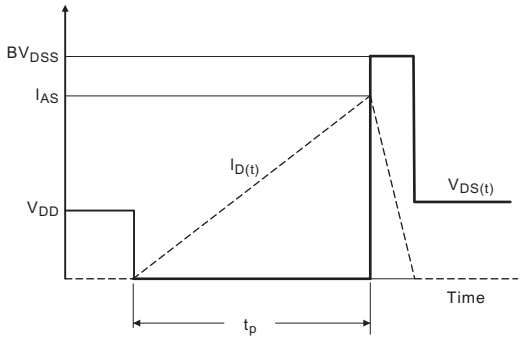


Fig.4B Unclamped Inductive switching waveforms



■ TYPICAL CHARACTERISTICS

Fig.1 Breakdown voltage variation vs. Temperature

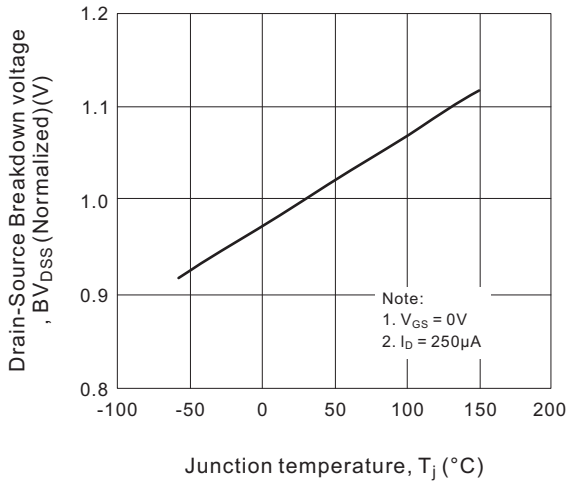


Fig.2 On-Resistance variation vs. junction vs. temperature

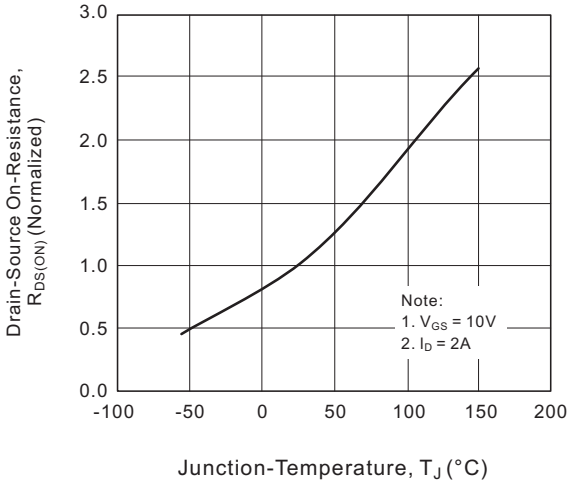


Fig.3-1 Maximum Safe operating area (for 4N60A)

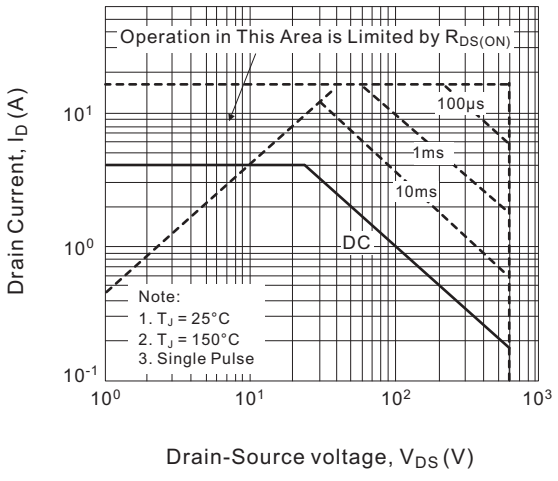


Fig.3-2 Maximum Safe operating area (for 4N60AF)

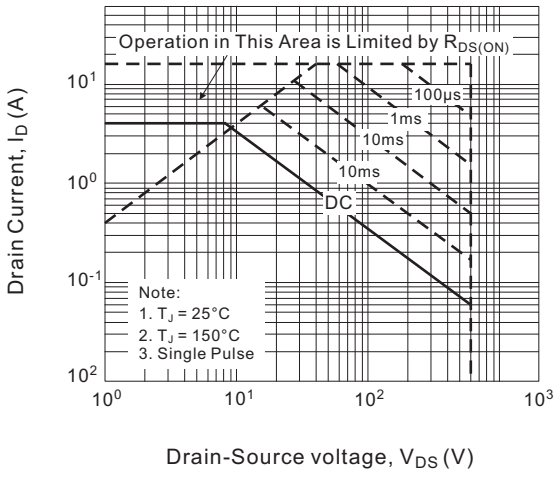


Fig.3-3 Maximum Safe operating area (for 4N60F/4N60G)

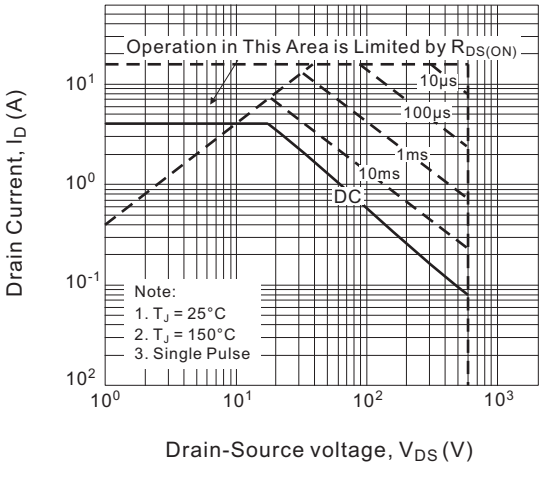
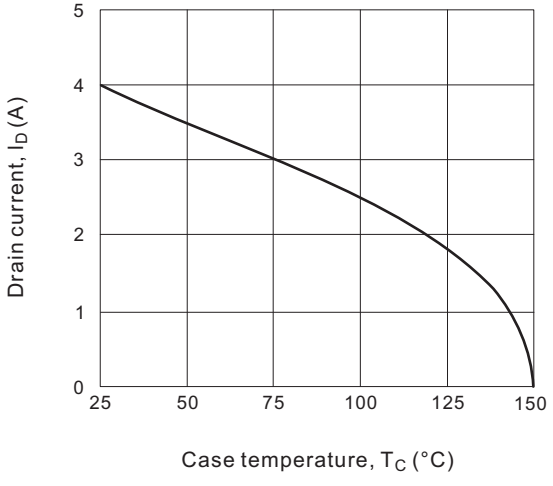


Fig.4 Maximum drain current vs. Case temperature



■ TYPICAL CHARACTERISTICS

Fig.5 On-State characteristics

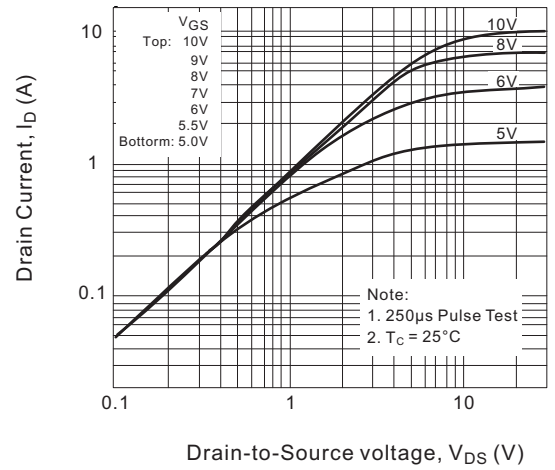


Fig.6 Transfer characteristics

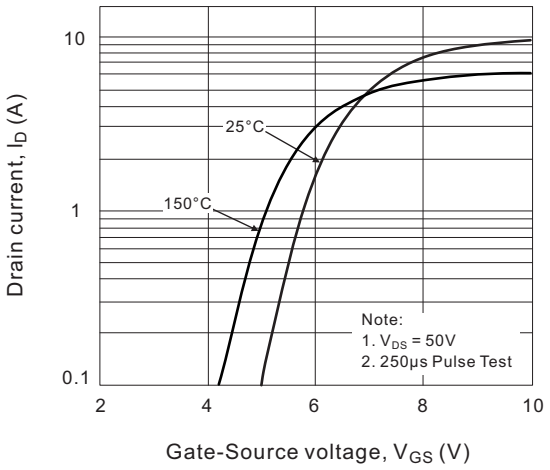


Fig.7 On-Resistance variation vs drain current and gate voltage

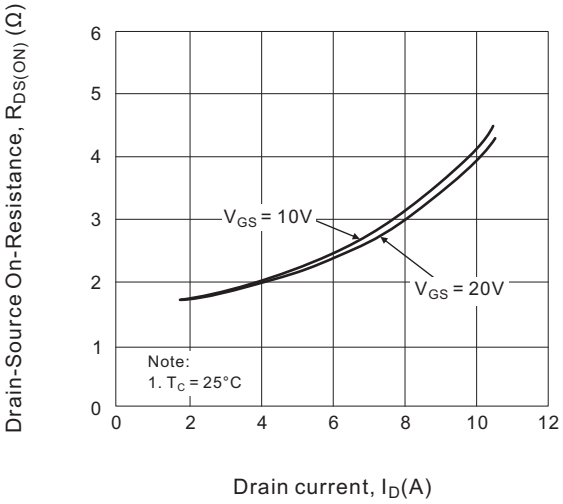


Fig.8 Body diode forward voltage variation vs. source current and temperature

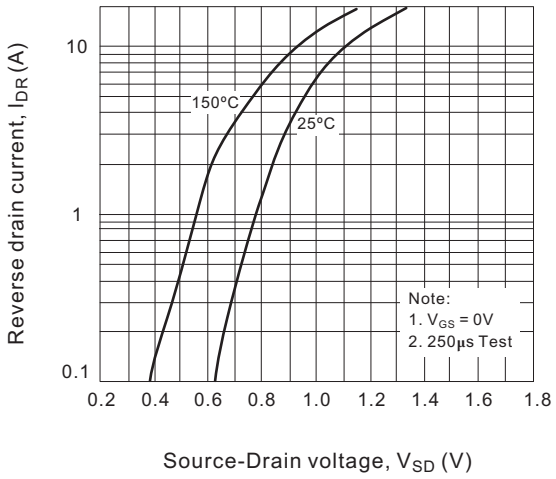


Fig.9 Capacitance characteristics (Non-Repetitive)

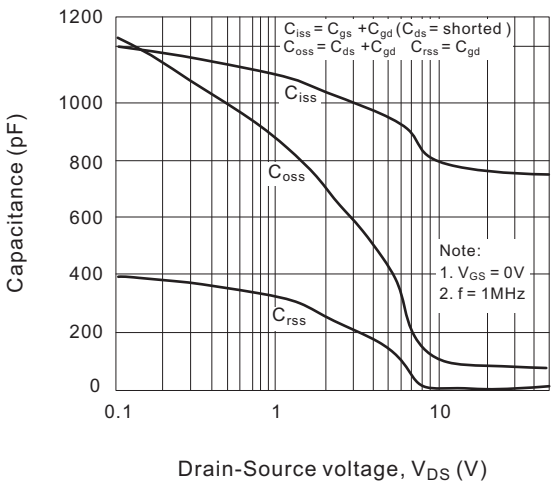
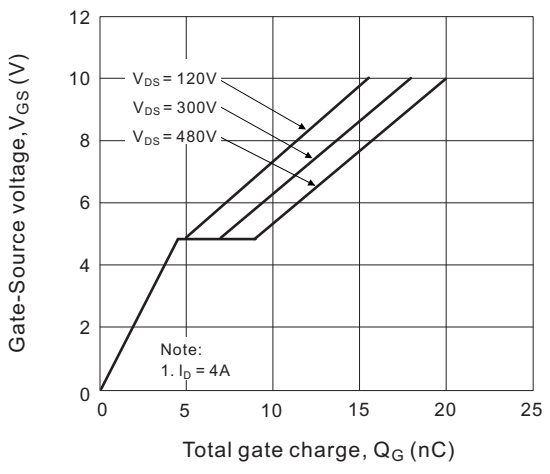


Fig.10 Gate charge characteristics



■ TYPICAL CHARACTERISTICS

Fig.11-1 Transient thermal response curve for 4N60A

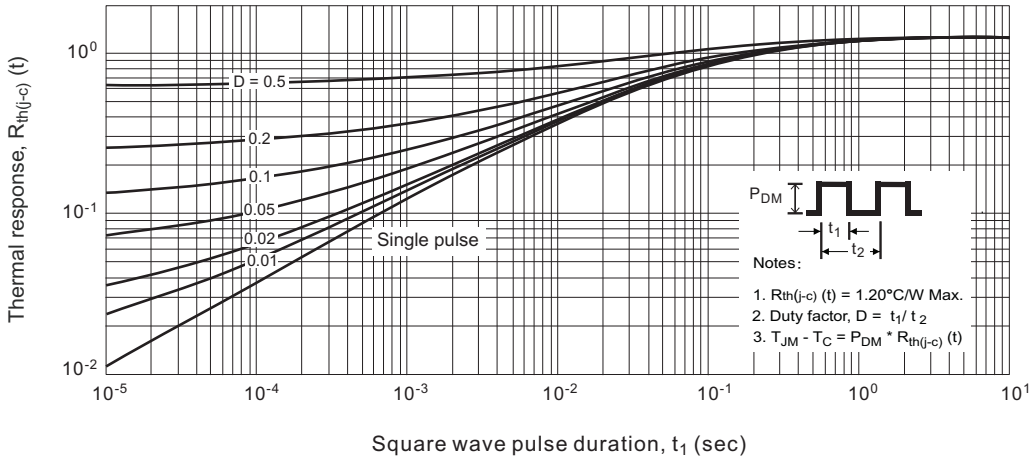


Fig.11-2 Transient thermal response curve for 4N60AF

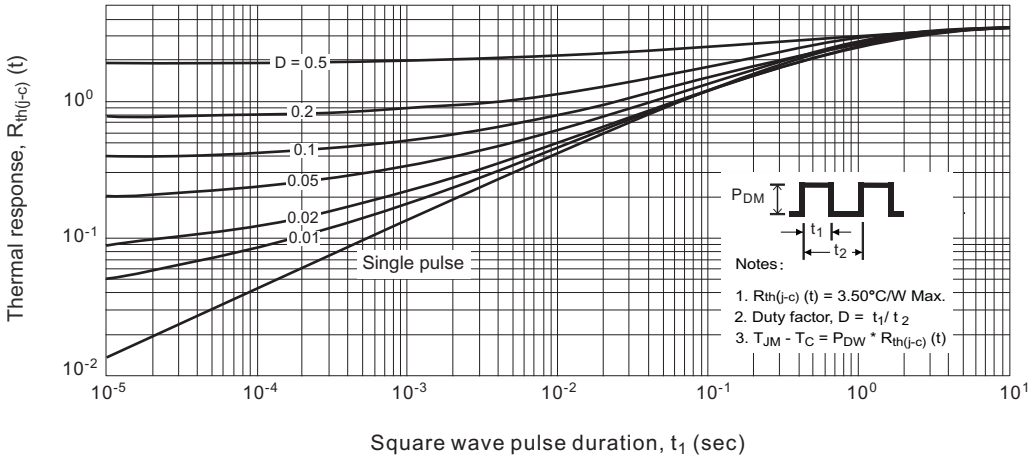
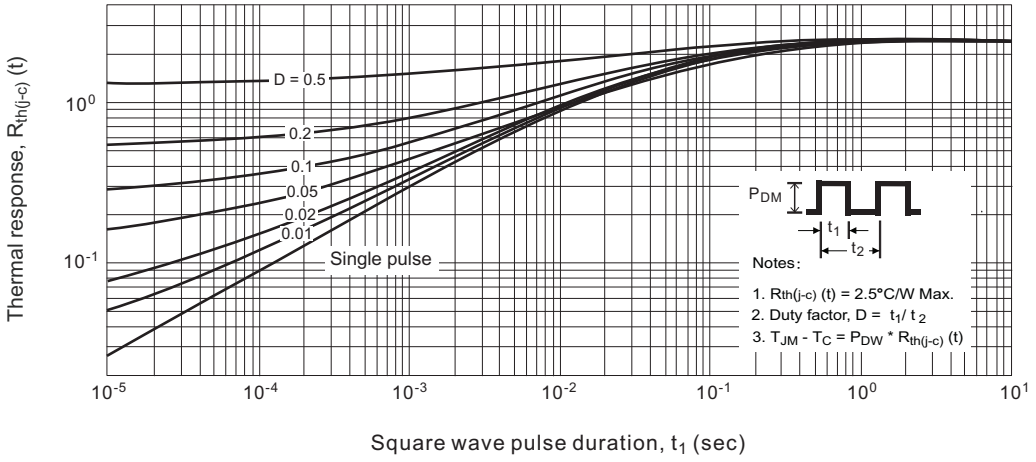


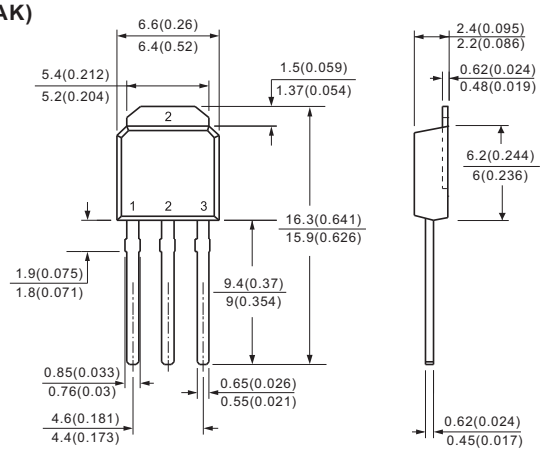
Fig.11-3 Transient thermal response curve (for 4N60F/4N60G)



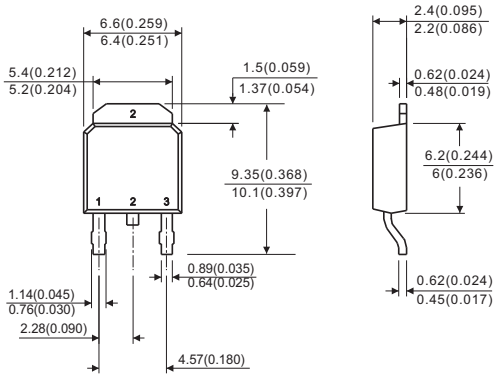
■ TYPICAL CHARACTERISTICS

Case Style

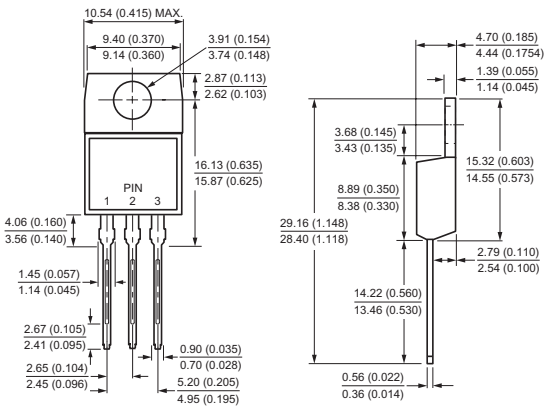
TO-251
(I-PAK)

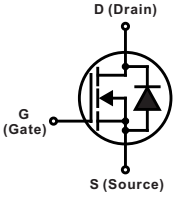


TO-252
(D-PAK)



TO-220AB

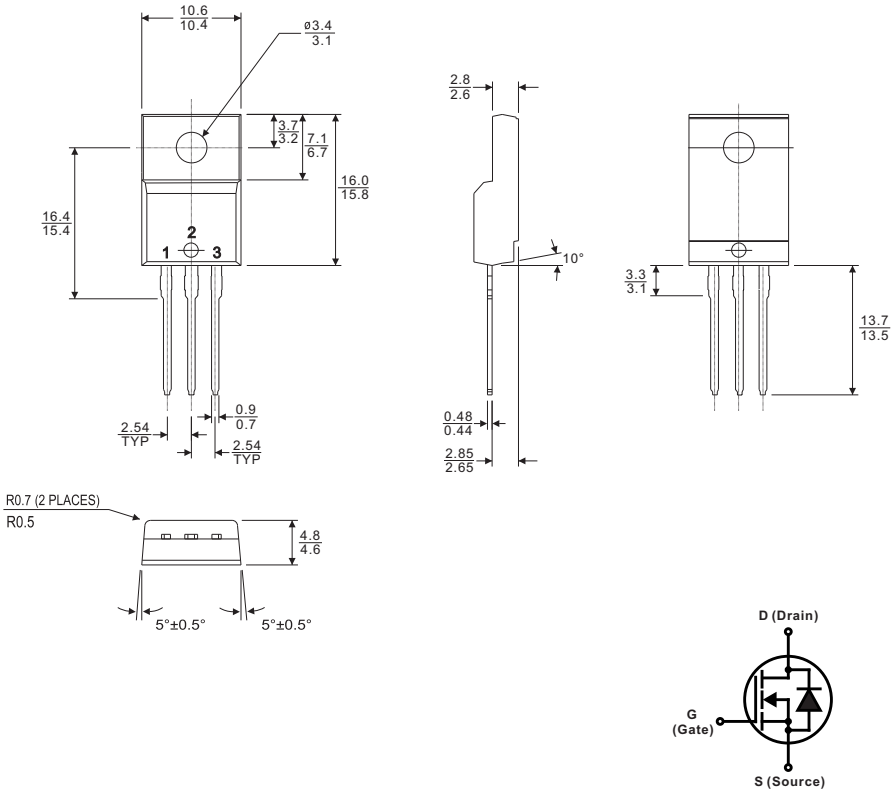




All dimensions in millimeters(inches)

Case Style

TO-220F



All dimensions in millimeters