

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

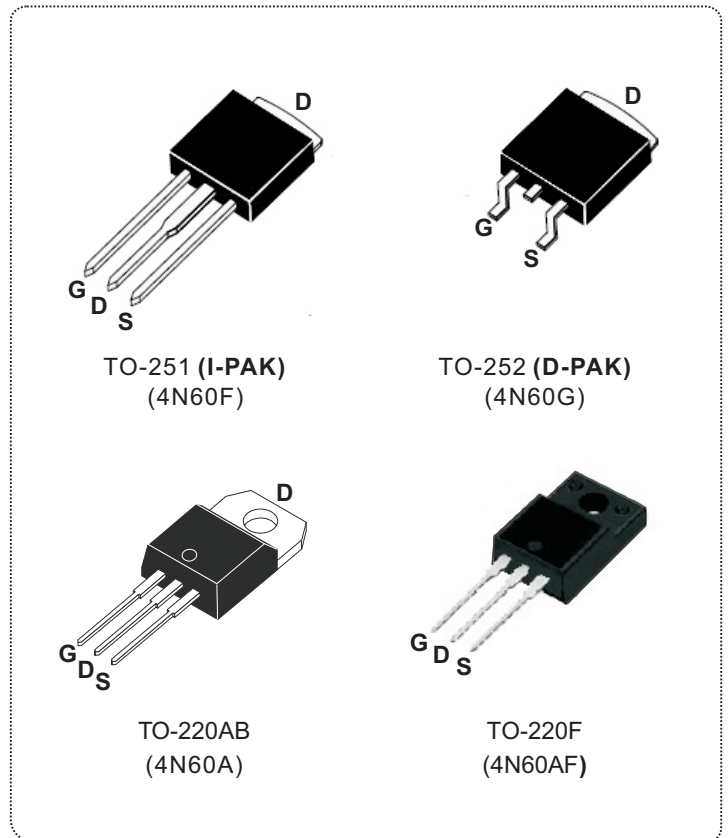
### DESCRIPTION

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.

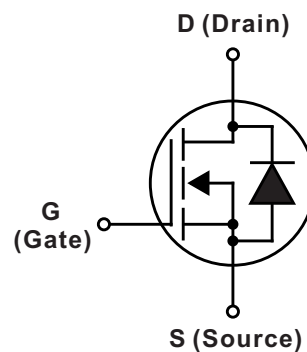
They are designed for use in applications such as switched mode power supplies, DC to DC converters, **PWM** motor controls, bridge circuits and general purpose switching applications.

### FEATURES

- $R_{DS(ON)} = 2.5\Omega @ V_{GS} = 10V$
- 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
$R_{DS(ON)}$ ( $\Omega$ )	2.5 @ $V_{GS} = 10V$
$Q_G$ (nC) max.	20

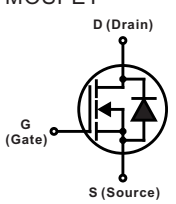


ABSOLUTE MAXIMUM RATINGS (T <sub>C</sub> = 25°C unless otherwise specified)					
SYMBOL	PARAMETER	TEST CONDITIONS		VALUE	UNIT
V <sub>DSS</sub>	Drain to Source voltage	T <sub>J</sub> =25°C to 150°C		600	V
V <sub>DGR</sub>	Drain to Gate voltage	R <sub>GS</sub> =20KΩ		600	
V <sub>GS</sub>	Gate to Source voltage			±30	
I <sub>D</sub>	Continuous Drain Current	T <sub>C</sub> =25°C		4	A
		T <sub>C</sub> =100°C		2.48	
I <sub>DM</sub>	Pulsed Drain current(Note 1)			16	
I <sub>AR</sub>	Avalanche current(Note 1)			4	
E <sub>AR</sub>	Repetitive avalanche energy(Note 1)	I <sub>AR</sub> =4A, R <sub>GS</sub> =50Ω, V <sub>GS</sub> =10V		10.6	mJ
E <sub>AS</sub>	Single pulse avalanche energy (Note 2)	I <sub>AS</sub> =4A, L = 30mH		260	
dv/dt	Peak diode recovery dv/dt(Note 3)			4.5	V/ns
P <sub>D</sub>	Total power dissipation (Derate above 25°C)	T <sub>C</sub> =25°C	TO-251/ TO-252	50 (0.39)	W(W/°C)
			TO-220AB	100 (0.8)	
			TO-220F	36 (0.26)	
T <sub>J</sub>	Operation junction temperature			-55 to 150	°C
T <sub>STG</sub>	Storage temperature			-55 to 150	
T <sub>L</sub>	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<sub>AS</sub> = 4A, V<sub>DD</sub> = 50V, L = 30mH, R<sub>GS</sub> = 25Ω, starting T<sub>J</sub>=25°C.  
 3.I<sub>SD</sub> ≤ 4A, di/dt ≤ 200A/μs, V<sub>DD</sub> ≤ V<sub>(BR)DSS</sub>, starting T<sub>J</sub>=25°C.

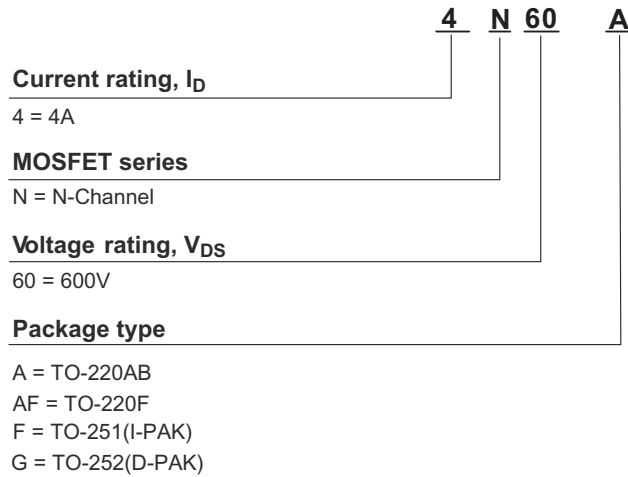
THERMAL RESISTANCE					
SYMBOL	PARAMETER	Min.	Typ.	Max.	UNIT
R <sub>th(j-c)</sub>	Thermal resistance, junction to case	TO-251/ TO-252		2.5	°C/W
		TO-220AB		1.2	
		TO-220F		3.5	
R <sub>th(j-a)</sub>	Thermal resistance, junction to ambient	TO-251/TO-252		85	
		TO-220AB		62.5	
		TO-220F		62.5	

ELECTRICAL CHARACTERISTICS (T <sub>C</sub> = 25°C unless otherwise specified)							
SYMBOL	PARAMETER	TEST CONDITIONS	Min.	Typ.	Max.	UNIT	
<b>○ OFF CHARACTERISTICS</b>							
V <sub>(BR)DSS</sub>	Drain to source breakdown voltage	I <sub>D</sub> = 250μA, V <sub>GS</sub> = 0V	600			V	
ΔV <sub>(BR)DSS</sub> /ΔT <sub>J</sub>	Breakdown voltage temperature coefficient	I <sub>D</sub> = 250μA, V <sub>DS</sub> = V <sub>GS</sub>		0.6		V/°C	
I <sub>DSS</sub>	Drain to source leakage current	V <sub>DS</sub> =600V, V <sub>GS</sub> =0V    T <sub>C</sub> = 25°C			10	μA	
		V <sub>DS</sub> =480V, V <sub>GS</sub> =0V    T <sub>C</sub> =125°C			100		
I <sub>GSS</sub>	Gate to source forward leakage current	V <sub>GS</sub> = 30V, V <sub>DS</sub> = 0V			100	nA	
	Gate to source reverse leakage current	V <sub>GS</sub> = -30V, V <sub>DS</sub> = 0V			-100		
<b>○ ON CHARACTERISTICS</b>							
R <sub>DS(ON)</sub>	Static drain to source on-state resistance	I <sub>D</sub> = 2A, V <sub>GS</sub> = 10V		2.2	2.5	Ω	
V <sub>GS(TH)</sub>	Gate threshold voltage	V <sub>GS</sub> =V <sub>DS</sub> , I <sub>D</sub> =250μA	2.0		4.0	V	
g <sub>FS</sub>	Forward transconductance	V <sub>DS</sub> =40V, I <sub>D</sub> =2A		4.7		S	
<b>○ DYNAMIC CHARACTERISTICS</b>							
C <sub>ISS</sub>	Input capacitance	V <sub>DS</sub> = 25V, V <sub>GS</sub> = 0V, f = 1MHz		520	670	pF	
C <sub>OSS</sub>	Output capacitance			70	90		
C <sub>RSS</sub>	Reverse transfer capacitance			8.0	11		
<b>○ SWITCHING CHARACTERISTICS</b>							
t <sub>d(ON)</sub>	Turn-on delay time	V <sub>DD</sub> = 300V, V <sub>GS</sub> = 10V, I <sub>D</sub> = 4A, R <sub>GS</sub> = 25Ω (Note 1, 2)		13	35	ns	
t <sub>r</sub>	Rise time			45	100		
t <sub>d(OFF)</sub>	Turn-off delay time			25	60		
t <sub>f</sub>	Fall time			35	80		
Q <sub>G</sub>	Total gate charge	V <sub>DD</sub> = 480V, V <sub>GS</sub> = 10V, I <sub>D</sub> = 4A (Note 1, 2)		15	20	nC	
Q <sub>GS</sub>	Gate to source charge			3.5			
Q <sub>GD</sub>	Gate to drain charge (Miller charge)			7.0			

SOURCE TO DRAIN DIODE RATINGS AND CHARACTERISTICS (T <sub>C</sub> = 25°C unless otherwise specified)							
SYMBOL	PARAMETER	TEST CONDITIONS	Min.	Typ.	Max.	UNIT	
V <sub>SD</sub>	Diode forward voltage	I <sub>SD</sub> = 4A, V <sub>GS</sub> = 0V			1.4	V	
I <sub>S</sub> (I <sub>SD</sub> )	Continuous source to drain current	Integral reverse P-N junction diode in the MOSFET 			4	A	
I <sub>SM</sub>	Pulsed source current				16		
t <sub>rr</sub>	Reverse recovery time	I <sub>SD</sub> = 4A, V <sub>GS</sub> = 0V, dI <sub>F</sub> /dt = 100A/μs		250		ns	
Q <sub>rr</sub>	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



## ■ TEST CIRCUITS AND WAVEFORMS

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

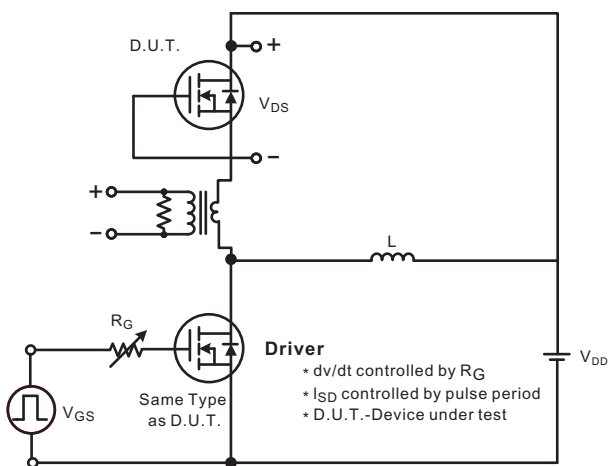
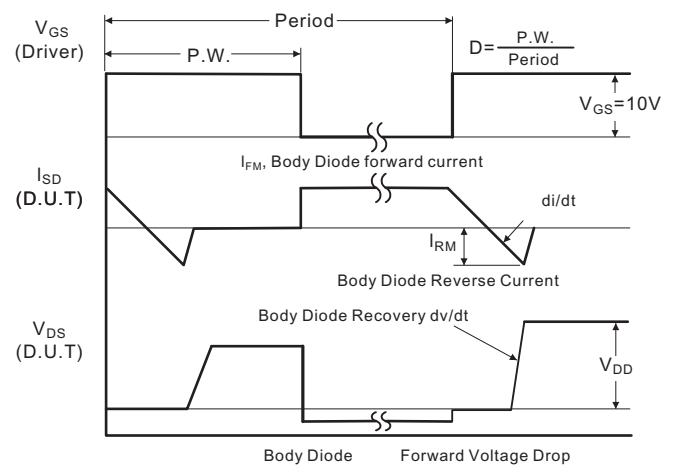


Fig.1B Peak diode recovery dv/dt waveforms



## TEST CIRCUITS AND WAVEFORMS (Cont.)

Fig.2A Switching test circuit

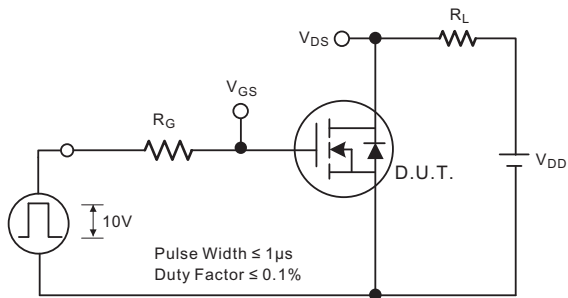


Fig.2B Switching Waveforms

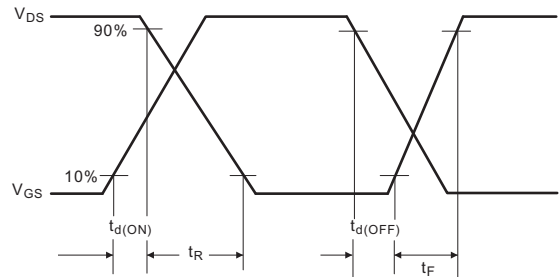


Fig.3A Gate charge test circuit

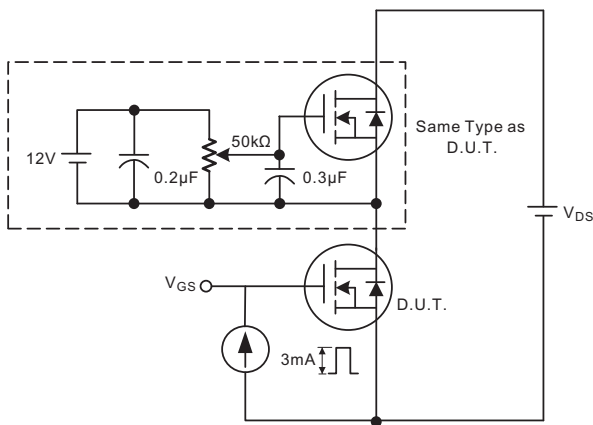


Fig.3B Gate charge waveform

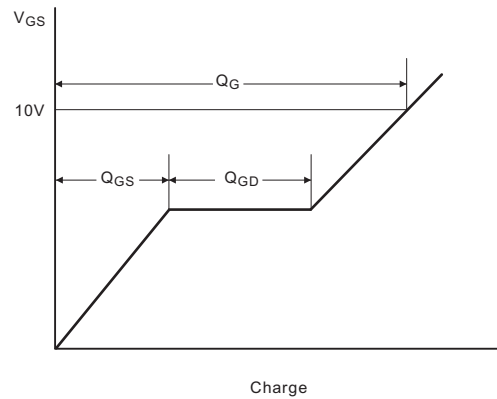


Fig.4A Unclamped Inductive switching test circuit

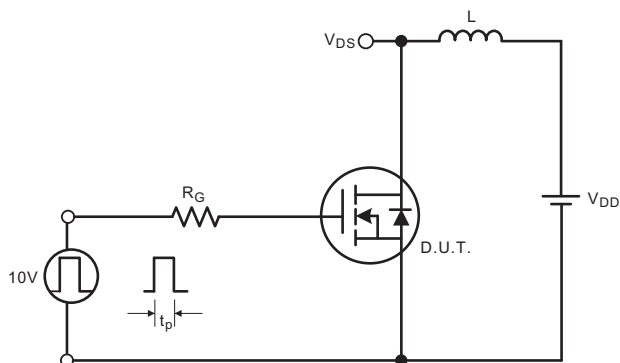
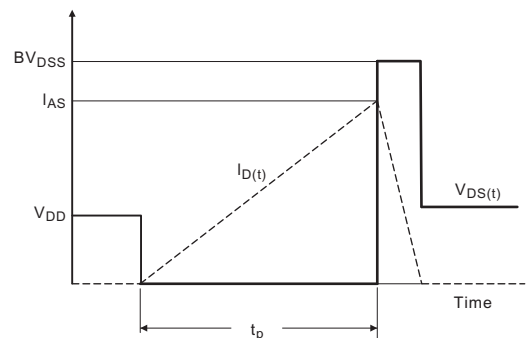
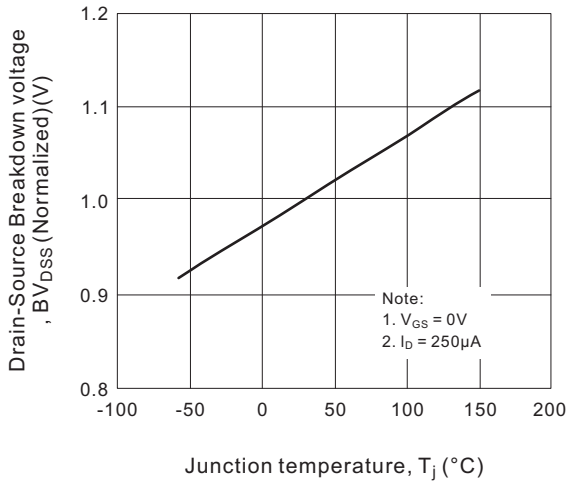


Fig.4B Unclamped Inductive switching waveforms

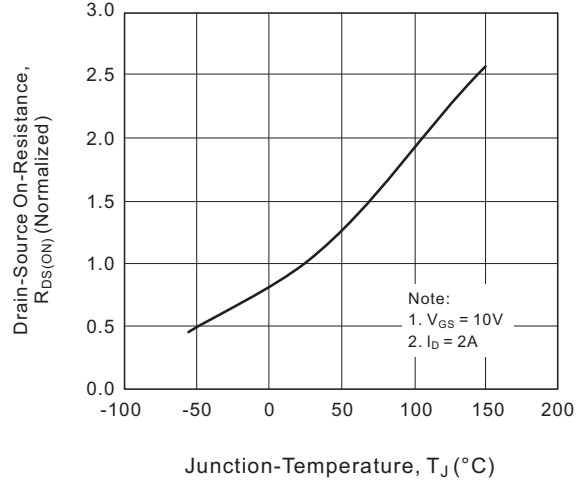


### TYPICAL CHARACTERISTICS

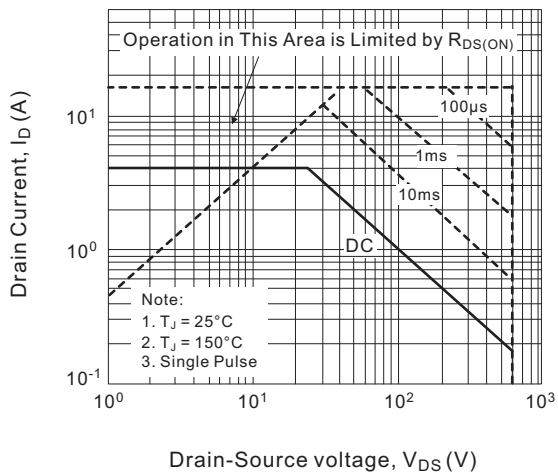
**Fig.1 Breakdown voltage variation vs. Temperature**



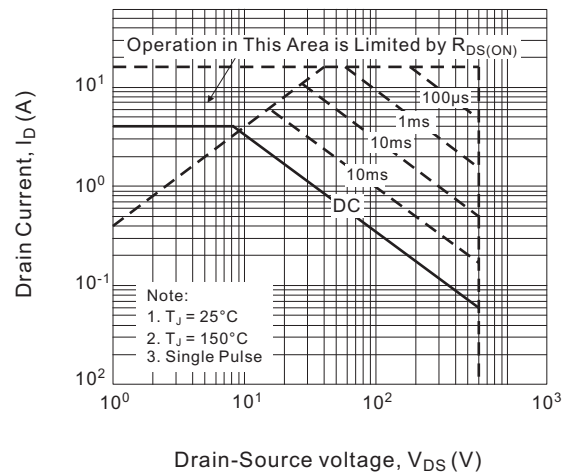
**Fig.2 On-Resistance variation vs. junction vs. temperature**



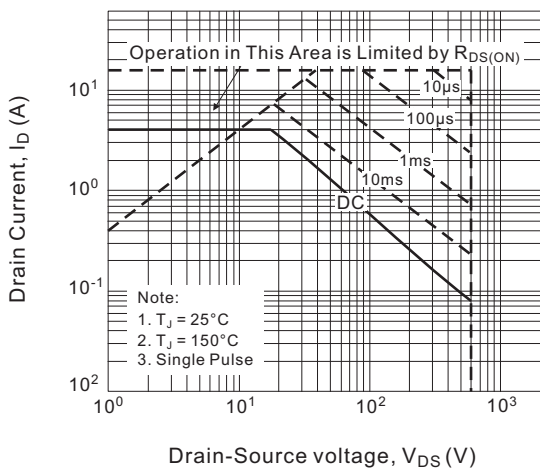
**Fig.3-1 Maximum Safe operating area (for 4N60A)**



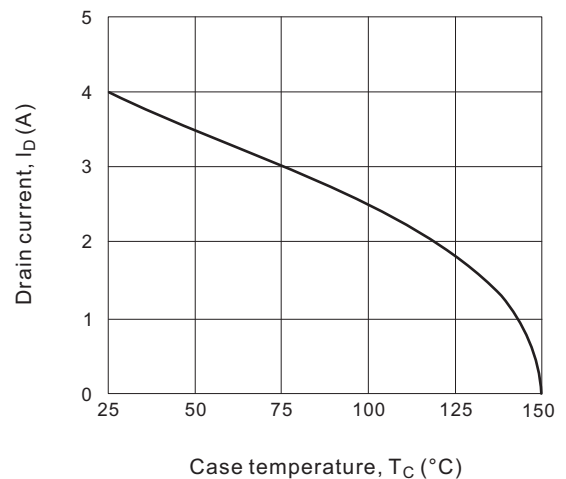
**Fig.3-2 Maximum Safe operating area (for 4N60AF)**



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

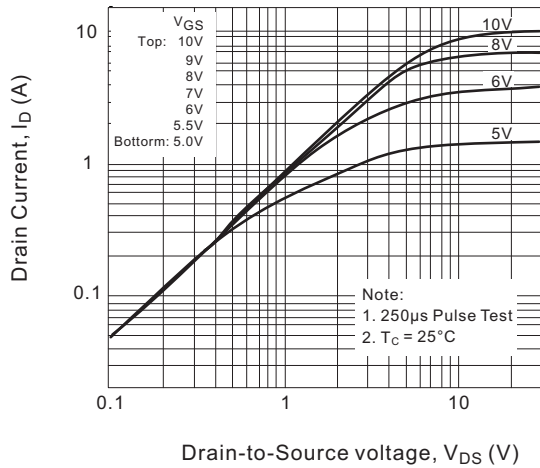


**Fig.4 Maximum drain current vs. Case temperature**

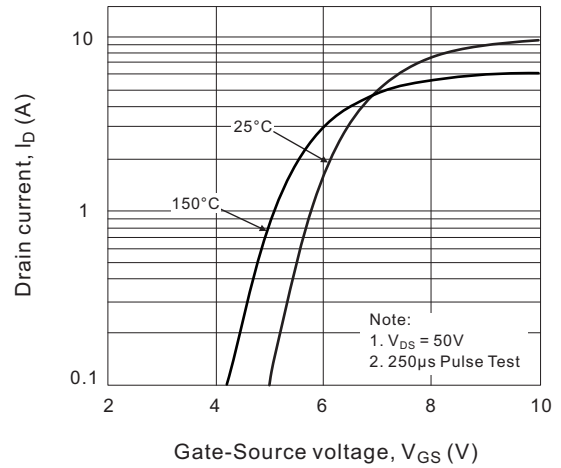


### ■ TYPICAL CHARACTERISTICS

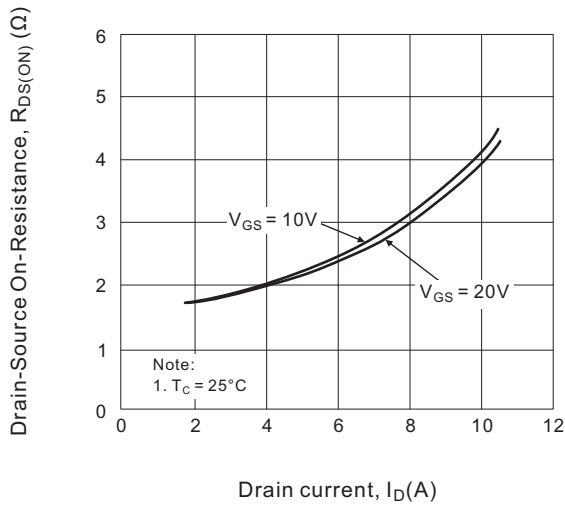
**Fig.5 On-State characteristics**



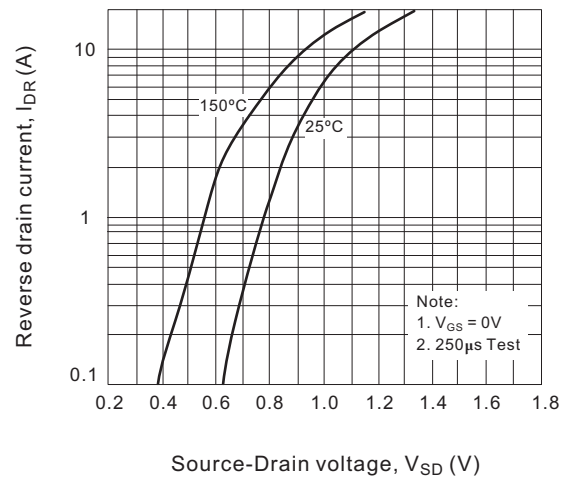
**Fig.6 Transfer characteristics**



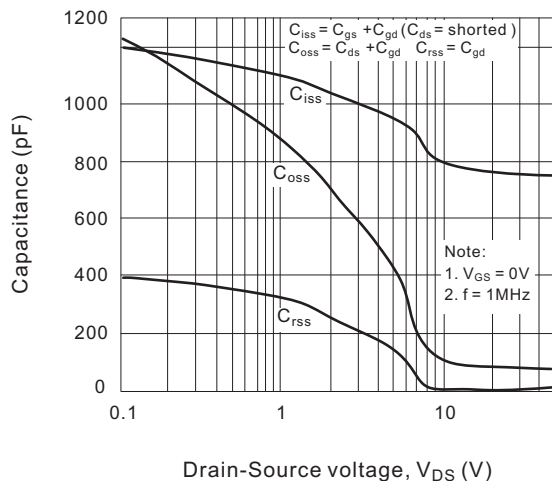
**Fig.7 On-Resistance variation vs drain current and gate voltage**



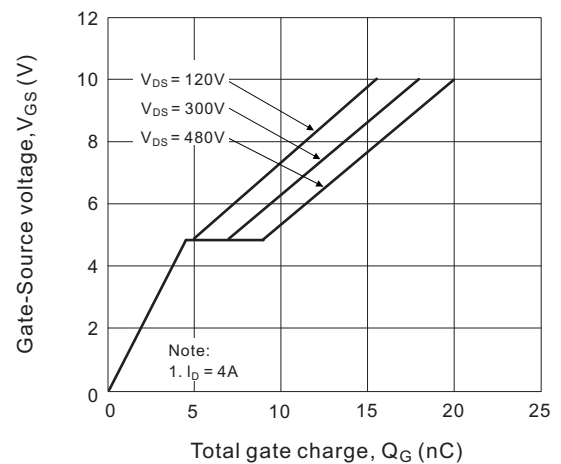
**Fig.8 Body diode forward voltage variation vs. source current and temperature**



**Fig.9 Capacitance characteristics (Non-Repetitive)**

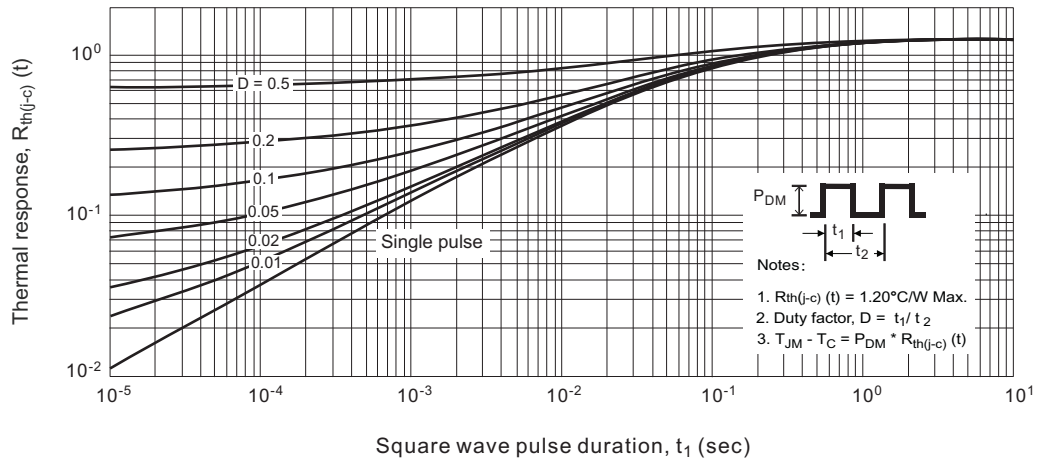


**Fig.10 Gate charge characteristics**

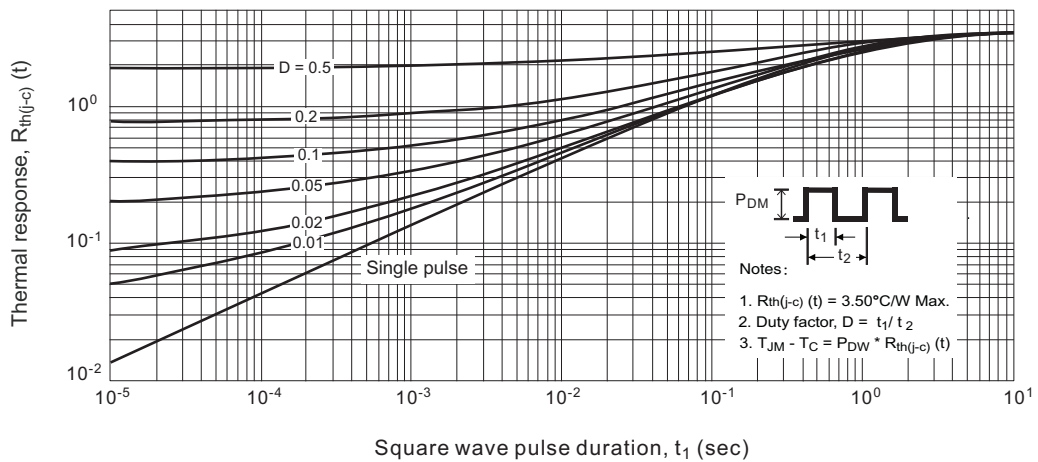


■ **TYPICAL CHARACTERISTICS**

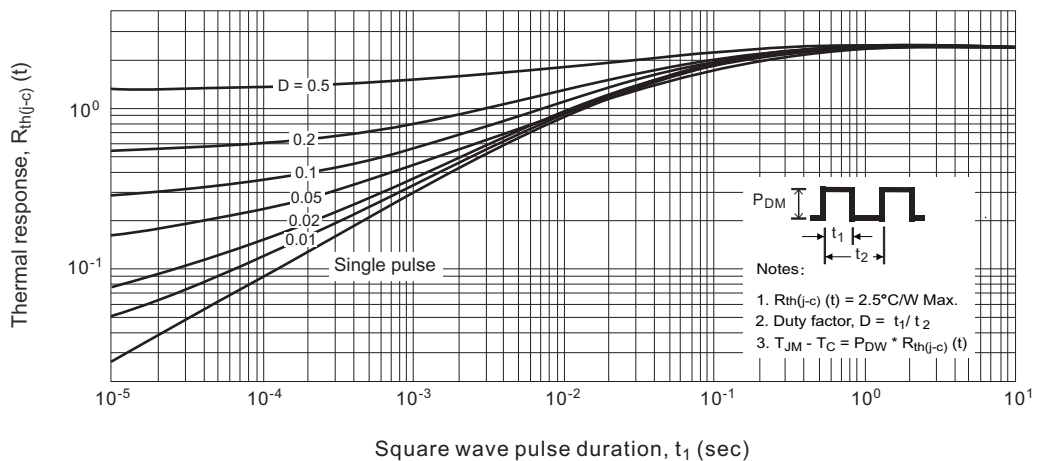
**Fig.11-1 Transient thermal response curve for 4N60A**



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



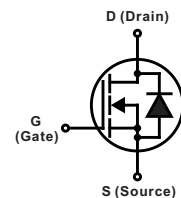
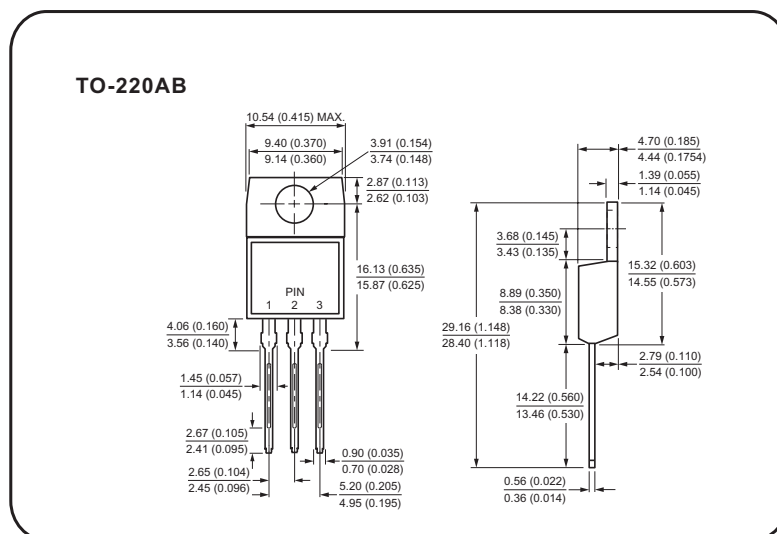
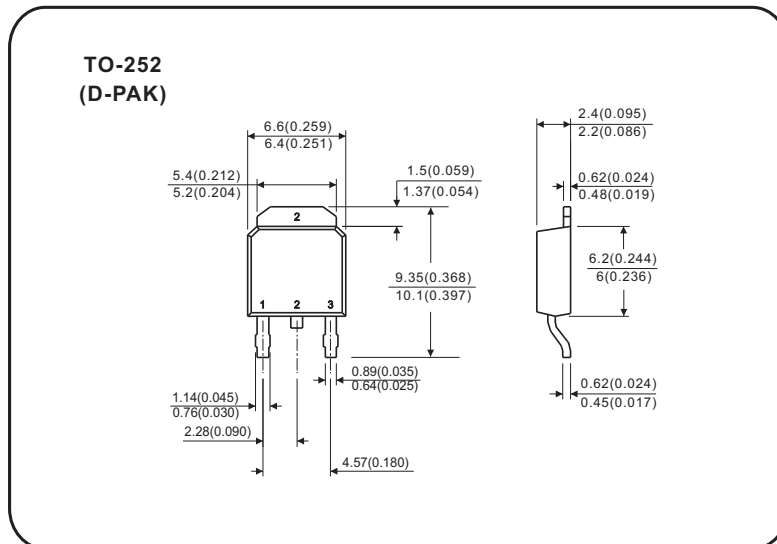
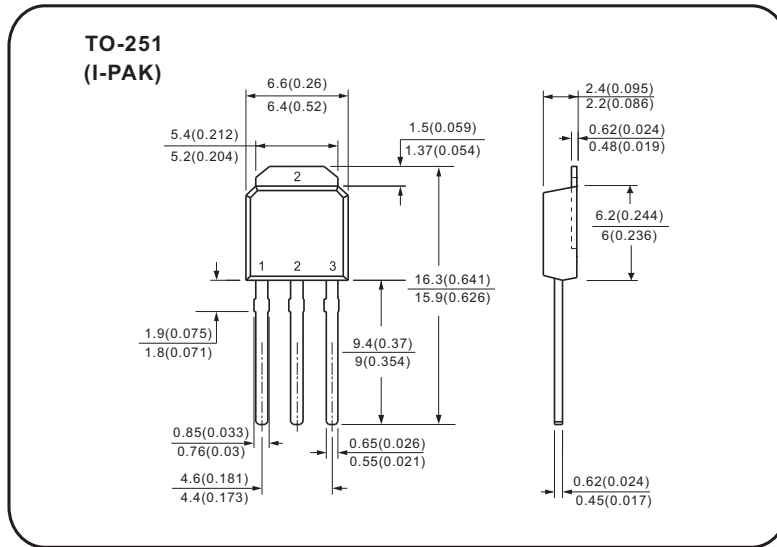
**Fig.11-3 Transient thermal response curve (for 4N60F/4N60G)**





### ■ TYPICAL CHARACTERISTICS

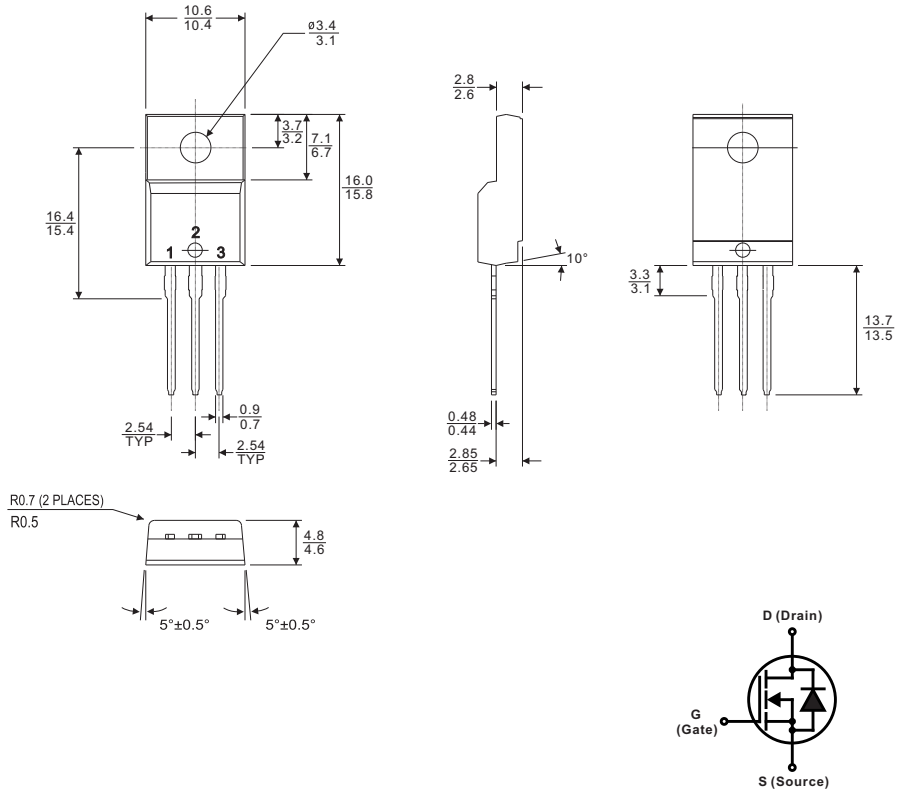
### Case Style



All dimensions in millimeters(inches)

**Case Style**

**TO-220F**



All dimensions in millimeters