

# MOSFET – N-Channel, SuperFET®

**600 V, 20 A, 190 mΩ**

**FCP20N60, FCPF20N60**

## Description

SuperFET MOSFET is onsemi's first generation of high voltage super-junction (SJ) MOSFET family that is utilizing charge balance technology for outstanding low onresistance and lower gate charge performance. This technology is tailored to minimize conduction loss, provide superior switching performance, dv/dt rate and higher avalanche energy. Consequently, SuperFET MOSFET is very suitable for the switching power applications such as PFC, server/telecom power, FPD TV power, ATX power and industrial power applications.

## Features

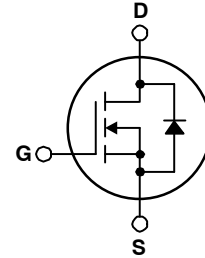
- 650 V @  $T_J = 150^\circ\text{C}$
- Typ.  $R_{DS(on)} = 150\text{ m}\Omega$
- Ultra Low Gate Charge (Typ.  $Q_g = 75\text{ nC}$ )
- Low Effective Output Capacitance (Typ.  $C_{oss(eff.)} = 165\text{ pF}$ )
- 100% Avalanche Tested
- These Devices are Pb-Free and are RoHS Compliant

## Applications

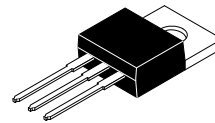
- Solar Inverter
- AC – DC Power Supply

$V_{DS}$	$R_{DS(on)} \text{ MAX}$	$I_D \text{ MAX}$
600 V	190 mΩ @ 10 V	20 A*

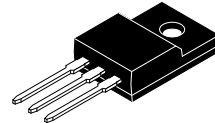
\*Drain current limited by maximum junction temperature.



**N-CHANNEL MOSFET**

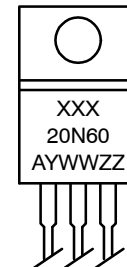


**TO-220-3LD  
CASE 340AT**



**TO-220 Fullpack, 3-Lead  
/ TO-220F-3SG  
CASE 221AT**

## MARKING DIAGRAM



XXX20N60 = Device Code (XXX = FCP, FCPF)  
 A = Assembly Location  
 YWW = Date Code (Year & Week)  
 ZZ = Assembly Lot

## ORDERING INFORMATION

Device	Package	Shipping
FCP20N60	TO-220	1000 Units / Tube
FCPF20N60	TO-220F	1000 Units / Tube

# FCP20N60, FCPF20N60

## MOSFET MAXIMUM RATINGS ( $T_C = 25^\circ\text{C}$ unless otherwise noted)

Symbol	Parameter		FCP20N60	FCPF20N60	Unit
$V_{DS}$	Drain-Source Voltage		600		V
$I_D$	Drain Current	- Continuous, $T_C = 25^\circ\text{C}$	20	20*	A
		- Continuous, $T_C = 100^\circ\text{C}$	12.5	12.5*	
		- Pulsed (Note 1)	60	60*	
$I_{DM}$					
$V_{GSS}$	Drain-Source Voltage		$\pm 30$		V
$E_{AS}$	Single Pulsed Avalanche Energy (Note 2)		690		mJ
$I_{AR}$	Avalanche Current (Note 1)		20		A
$E_{AR}$	Repetitive Avalanche Energy (Note 1)		20.8		mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ (Note 3)		4.5		V/ns
$P_D$	Power Dissipation	$T_C = 25^\circ\text{C}$	208	39	W
		-Derate above $= 25^\circ\text{C}$	1.67	0.3	W/ $^\circ\text{C}$
$T_J, T_{STG}$	Operating and Storage Temperature Range		$-55$ to $+150$		$^\circ\text{C}$
$T_L$	Maximum Lead Temperature for Soldering, 1/8" from Case for 5 Seconds		300		$^\circ\text{C}$

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

\*Drain current limited by maximum junction temperature.

1. Repetitive rating: pulse-width limited by maximum junction temperature.
2.  $I_{AS} = 10\text{ A}$ ,  $V_{DD} = 50\text{ V}$ ,  $R_G = 25\ \Omega$ , starting  $T_J = 25^\circ\text{C}$ .
3.  $I_{SD} \leq 20\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq BV_{DSS}$ , starting  $T_J = 25^\circ\text{C}$ .

## THERMAL CHARACTERISTICS

Symbol	Parameter	FCP20N60	FCPF20N60	Unit
$R_{\theta JC}$	Thermal Resistance, Junction to Case	0.6	3.2	$^\circ\text{C}/\text{W}$
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	62.5	62.5	

# FCP20N60, FCPF20N60

## ELECTRICAL CHARACTERISTICS (T<sub>J</sub> = 25°C unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
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### OFF CHARACTERISTICS

BV <sub>DSS</sub>	Drain to Source Breakdown Voltage	I <sub>D</sub> = 250 μA, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 25°C	600	–	–	V
		I <sub>D</sub> = 250 μA, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 150°C	–	650	–	V
$\frac{\Delta BV_{DSS}}{\Delta T_J}$	Breakdown Voltage Temperature Coefficient	I <sub>D</sub> = 250 μA, referenced to 25°C	–	0.6	–	V/°C
BV <sub>DS</sub>	Drain–Source Avalanche Breakdown Voltage	V <sub>GS</sub> = 0 V, I <sub>D</sub> = 20 A	–	700	–	V
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	V <sub>DS</sub> = 600 V, V <sub>GS</sub> = 0 V	–	–	1	μA
		V <sub>DS</sub> = 480 V, T <sub>C</sub> = 125°C	–	–	10	
I <sub>GSS</sub>	Gate to Body Leakage Current	V <sub>GS</sub> = ±30 V, V <sub>DS</sub> = 0 V	–	–	±100	μA

### ON CHARACTERISTICS

V <sub>GS(th)</sub>	Gate Threshold Voltage	V <sub>GS</sub> = V <sub>DS</sub> , I <sub>D</sub> = 250 μA	3.0	–	5.0	V
R <sub>DS(on)</sub>	Static Drain to Source On Resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 10 A	–	0.15	0.19	Ω
g <sub>FS</sub>	Forward Transconductance	V <sub>DS</sub> = 40 V, I <sub>D</sub> = 10 A	–	17	–	S

### DYNAMIC CHARACTERISTICS

C <sub>iss</sub>	Input Capacitance	V <sub>DS</sub> = 25 V, V <sub>GS</sub> = 0 V, f = 1 MHz	–	2370	3080	pF
C <sub>oss</sub>	Output Capacitance		–	1280	1665	pF
C <sub>rss</sub>	Reverse Transfer Capacitance		–	95	–	pF
C <sub>oss</sub>	Output Capacitance	V <sub>DS</sub> = 480 V, V <sub>GS</sub> = 0 V, f = 1 MHz	–	65	85	pF
C <sub>oss(eff.)</sub>	Effective Output Capacitance	V <sub>DS</sub> = 0 V, V <sub>GS</sub> = 400 V, V <sub>GS</sub> = 0 V	–	165	–	pF
Q <sub>g(tot)</sub>	Total Gate Charge at 10 V	V <sub>DS</sub> = 480 V, I <sub>D</sub> = 20 A, V <sub>GS</sub> = 10 V (Note 4)	–	75	98	nC
Q <sub>gs</sub>	Gate to Source Gate Charge		–	13.5	18	nC
Q <sub>gd</sub>	Gate to Drain “Miller” Charge		–	36	–	nC

### SWITCHING CHARACTERISTICS

t <sub>d(on)</sub>	Turn–On Delay Time	V <sub>DD</sub> = 300 V, I <sub>D</sub> = 20 A, V <sub>GS</sub> = 10 V, R <sub>G</sub> = 25 Ω (Note 4)	–	62	135	ns
t <sub>r</sub>	Turn–On Rise Time		–	140	290	ns
t <sub>d(off)</sub>	Turn–Off Delay Time		–	230	470	ns
t <sub>f</sub>	Turn–Off Fall Time		–	65	140	ns

### DRAIN–SOURCE DIODE CHARACTERISTICS

I <sub>S</sub>	Maximum Continuous Drain to Source Diode Forward Current		–	–	20	A
I <sub>SM</sub>	Maximum Pulsed Drain to Source Diode Forward Current		–	–	60	A
V <sub>SD</sub>	Drain to Source Diode Forward Voltage	V <sub>GS</sub> = 0 V, I <sub>SD</sub> = 20 A	–	–	1.4	V
t <sub>rr</sub>	Reverse Recovery Time	V <sub>GS</sub> = 0 V, I <sub>SD</sub> = 20 A, dI <sub>F</sub> /dt = 100 A/μs	–	530	–	ns
Q <sub>rr</sub>	Reverse Recovery Charge		–	10.5	–	μC

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

4. Essentially independent of operating temperature typical characteristics.

TYPICAL PERFORMANCE CHARACTERISTICS

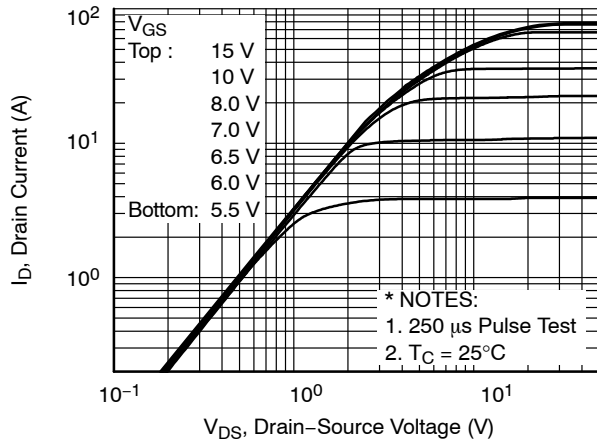


Figure 1. On-Region Characteristics

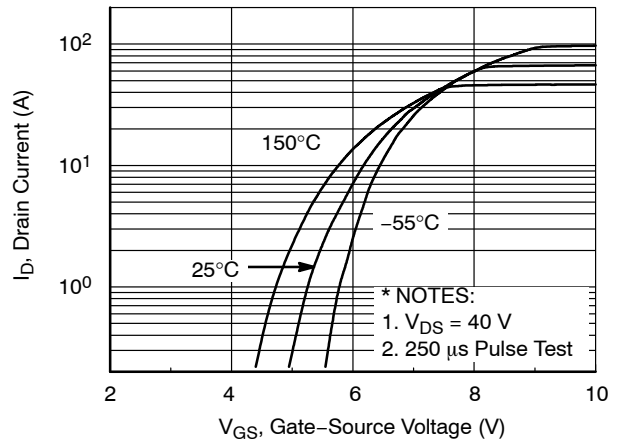


Figure 2. Transfer Characteristics

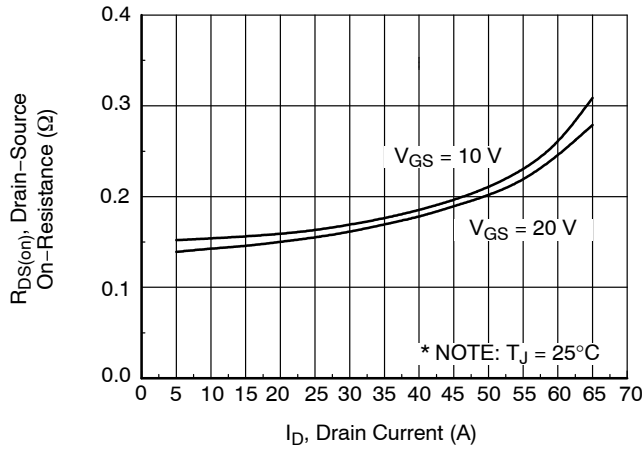


Figure 3. On-Resistance Variation vs. Drain Current and Gate Voltage

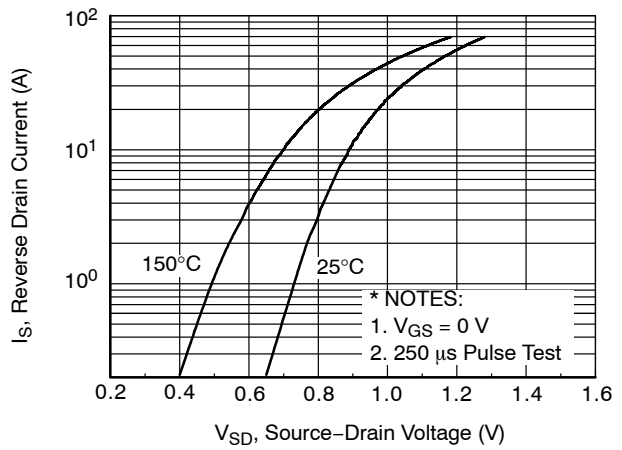


Figure 4. Body Diode Forward Voltage Variation vs. Source Current and Temperature

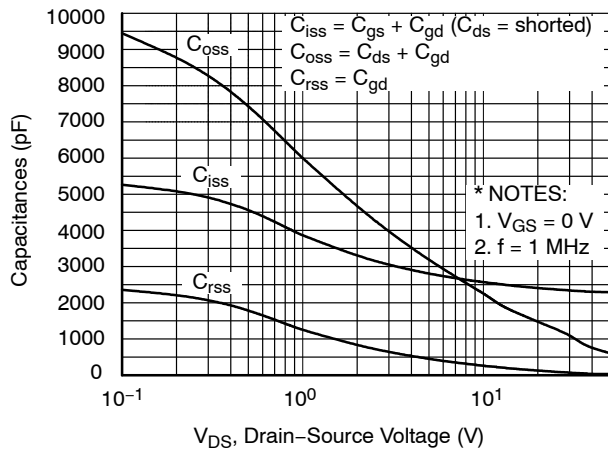


Figure 5. Capacitance Characteristics

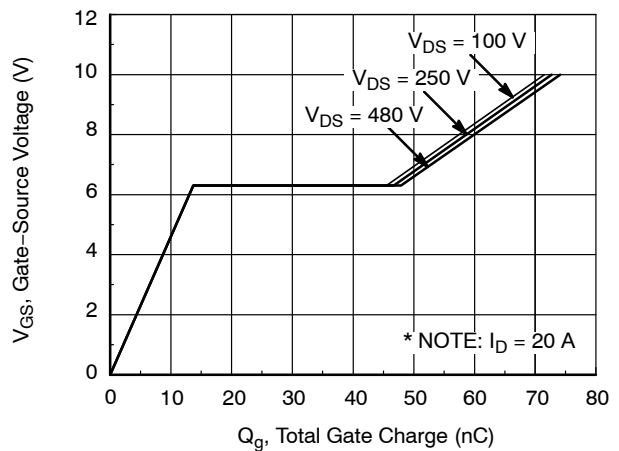
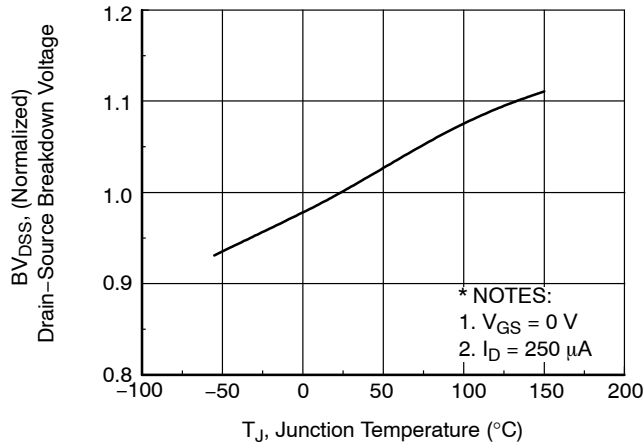


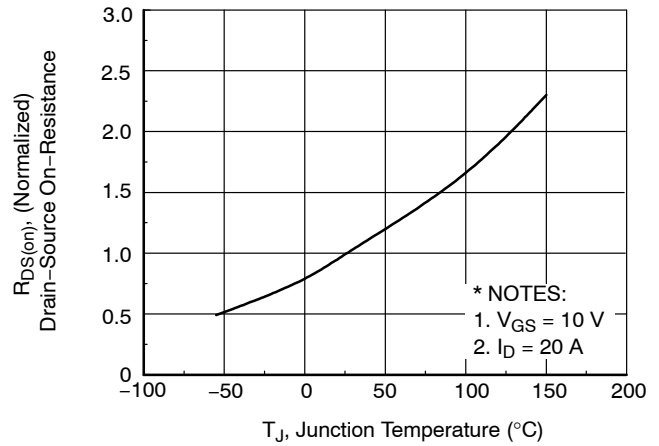
Figure 6. Gate Charge Characteristics

# FCP20N60, FCPF20N60

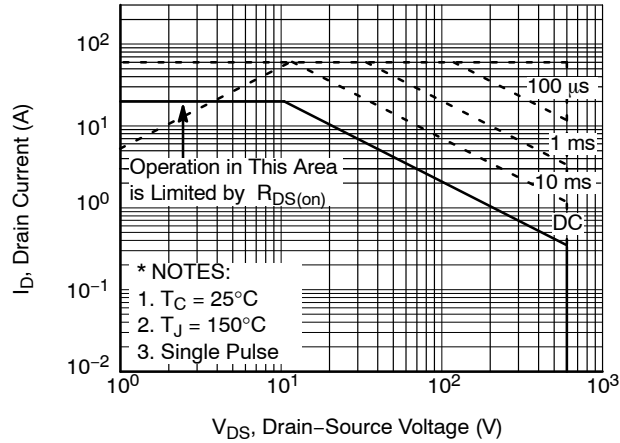
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)



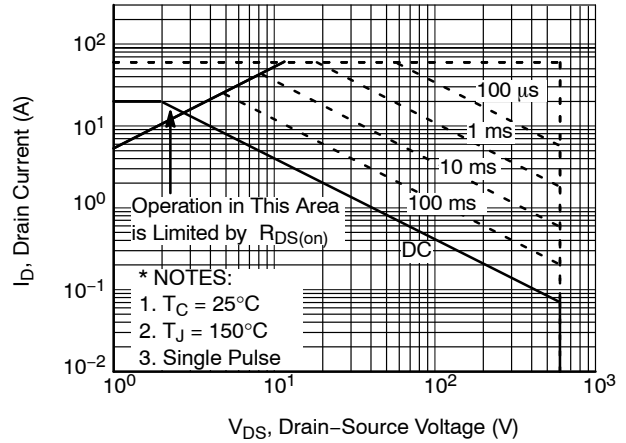
**Figure 7. Breakdown Voltage Variation vs. Temperature**



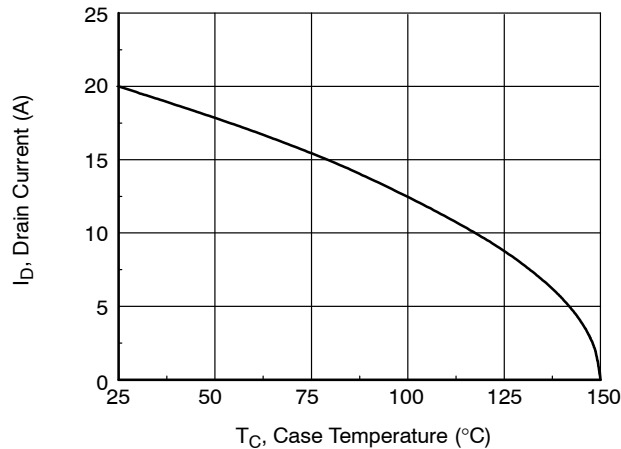
**Figure 8. On-Resistance Variation vs. Temperature**



**Figure 9. Maximum Safe Operating Area for FCP20N60**



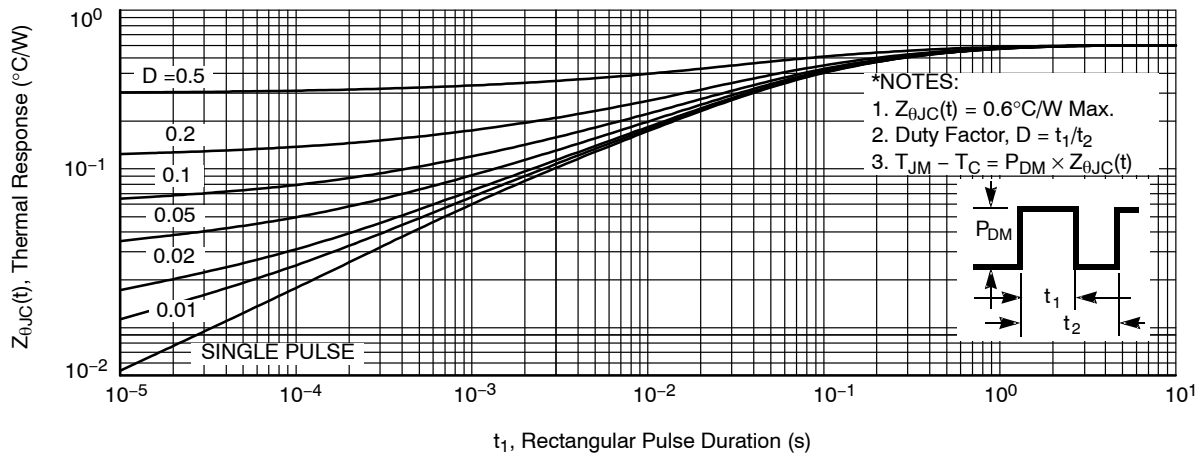
**Figure 10. Maximum Safe Operating Area for FCPF20N60**



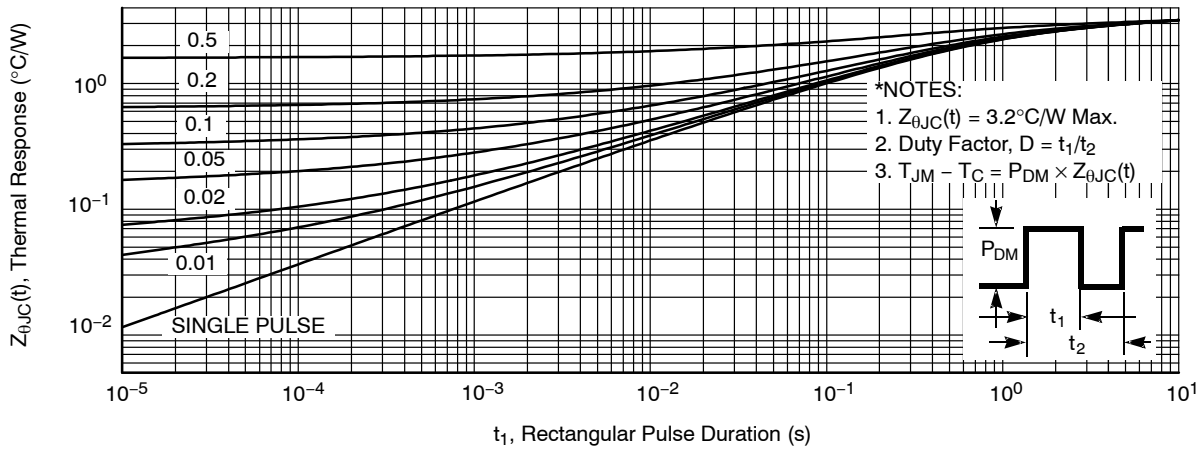
**Figure 11. Maximum Drain Current vs. Case Temperature**

# FCP20N60, FCPF20N60

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)



**Figure 12. Transient Thermal Response Curve for FCP20N60**



**Figure 13. Transient Thermal Response Curve for FCPF20N60**

## FCP20N60, FCPF20N60

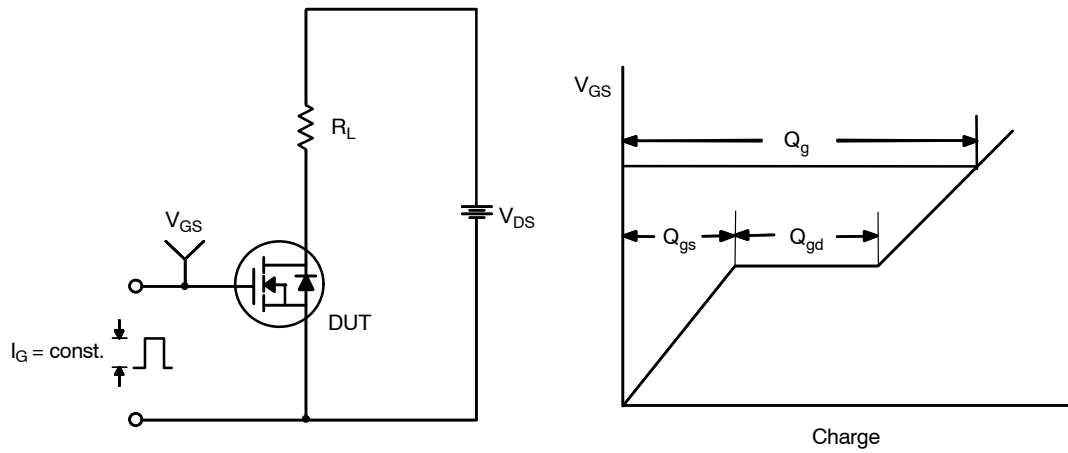


Figure 14. Gate Charge Test Circuit & Waveform

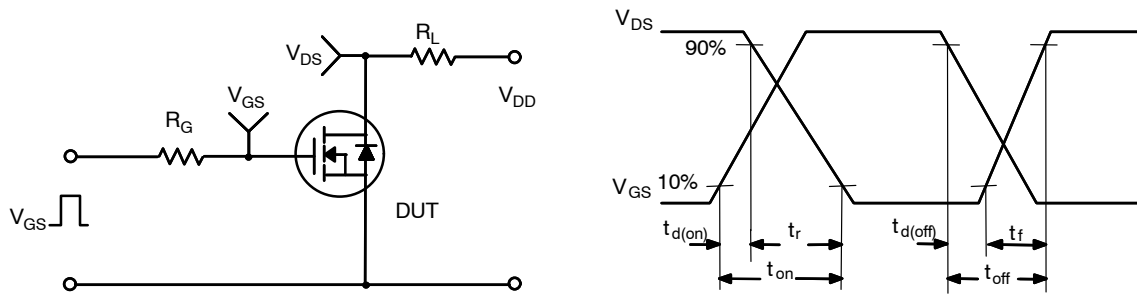


Figure 15. Resistive Switching Test Circuit & Waveforms

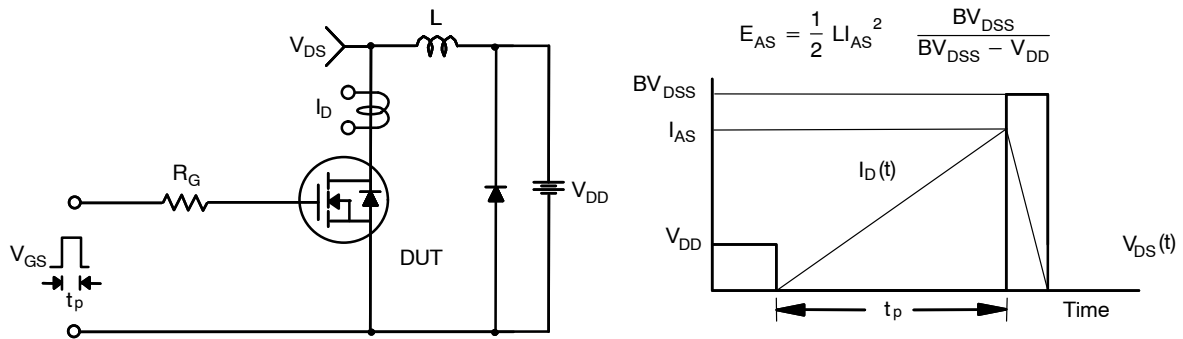
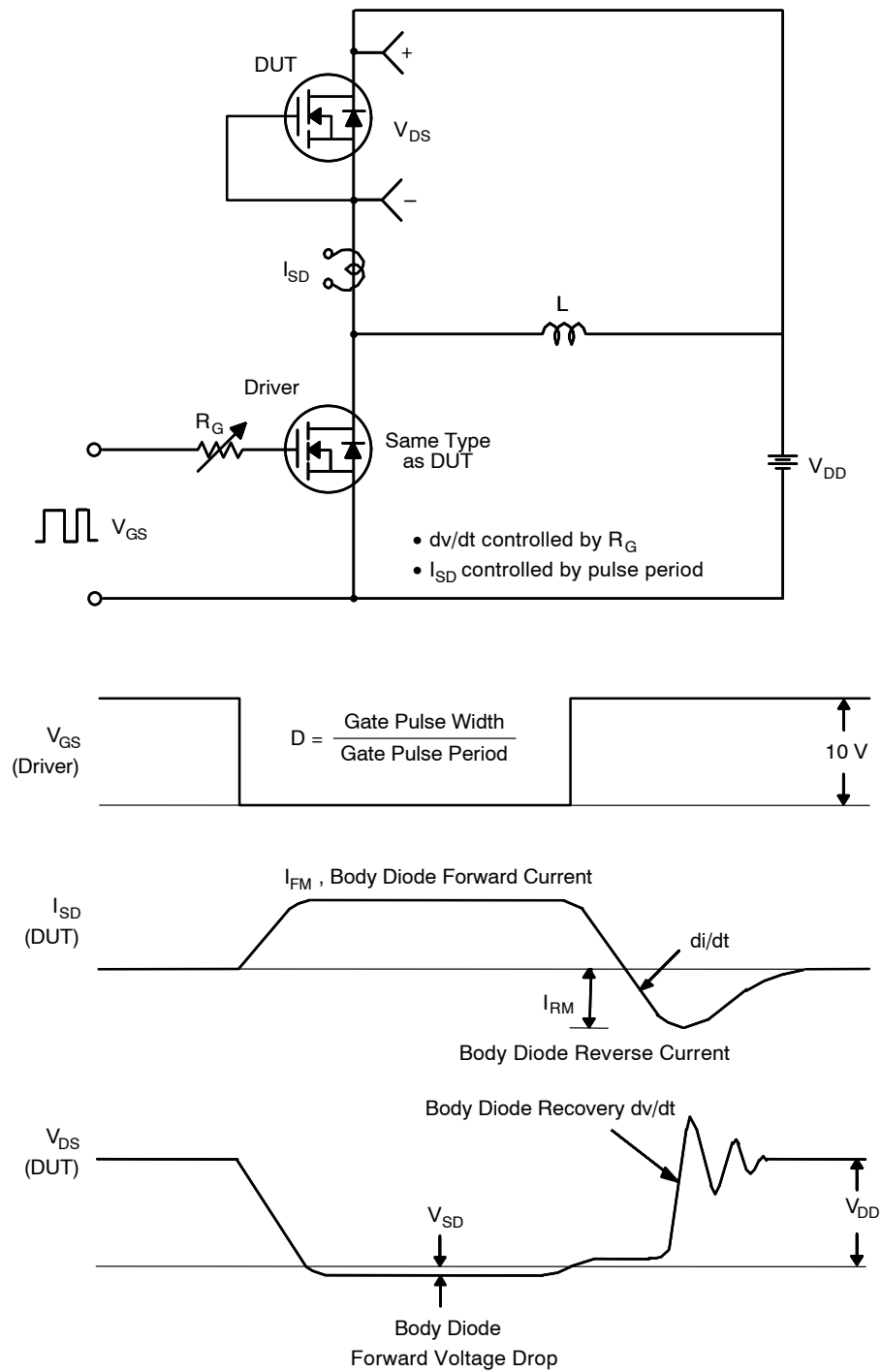


Figure 16. Unclamped Inductive Switching Test Circuit & Waveforms

## FCP20N60, FCPF20N60



**Figure 17. Peak Diode Recovery  $dv/dt$  Test Circuit & Waveforms**



**TO-220 Fullpack, 3-Lead / TO-220F-3SG**  
**CASE 221AT**  
**ISSUE B**

DATE 19 JAN 2021



Scale 1:1



OPTION1



DIM	MILLIMETERS		
	MIN	NOM	MAX
A	4.50	4.70	4.90
A1	2.56	2.76	2.96
A2	2.34	2.54	2.74
b	0.70	0.80	0.90
b2	~	~	1.47
c	0.45	0.50	0.60
D	15.67	15.87	16.07
D1	15.60	15.80	16.00
E	9.96	10.16	10.36
e	2.34	2.54	2.74
F	~	0.84	~
H1	6.48	6.68	6.88
L	12.78	12.98	13.18
L1	3.03	3.23	3.43
Ø P	2.98	3.18	3.38
Ø P1	~	1.00	~
Q	3.20	3.30	3.40

**NOTES:**

A. DIMENSION AND TOLERANCE AS ASME Y14.5-2009

B. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR PROTRUCTIONS.

C. OPTION 1 - WITH SUPPORT PIN HOLE

OPTION 2 - NO SUPPORT PIN HOLE

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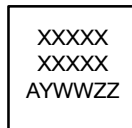
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**TO-220-3LD**  
**CASE 340AT**  
**ISSUE B**

DATE 08 AUG 2022

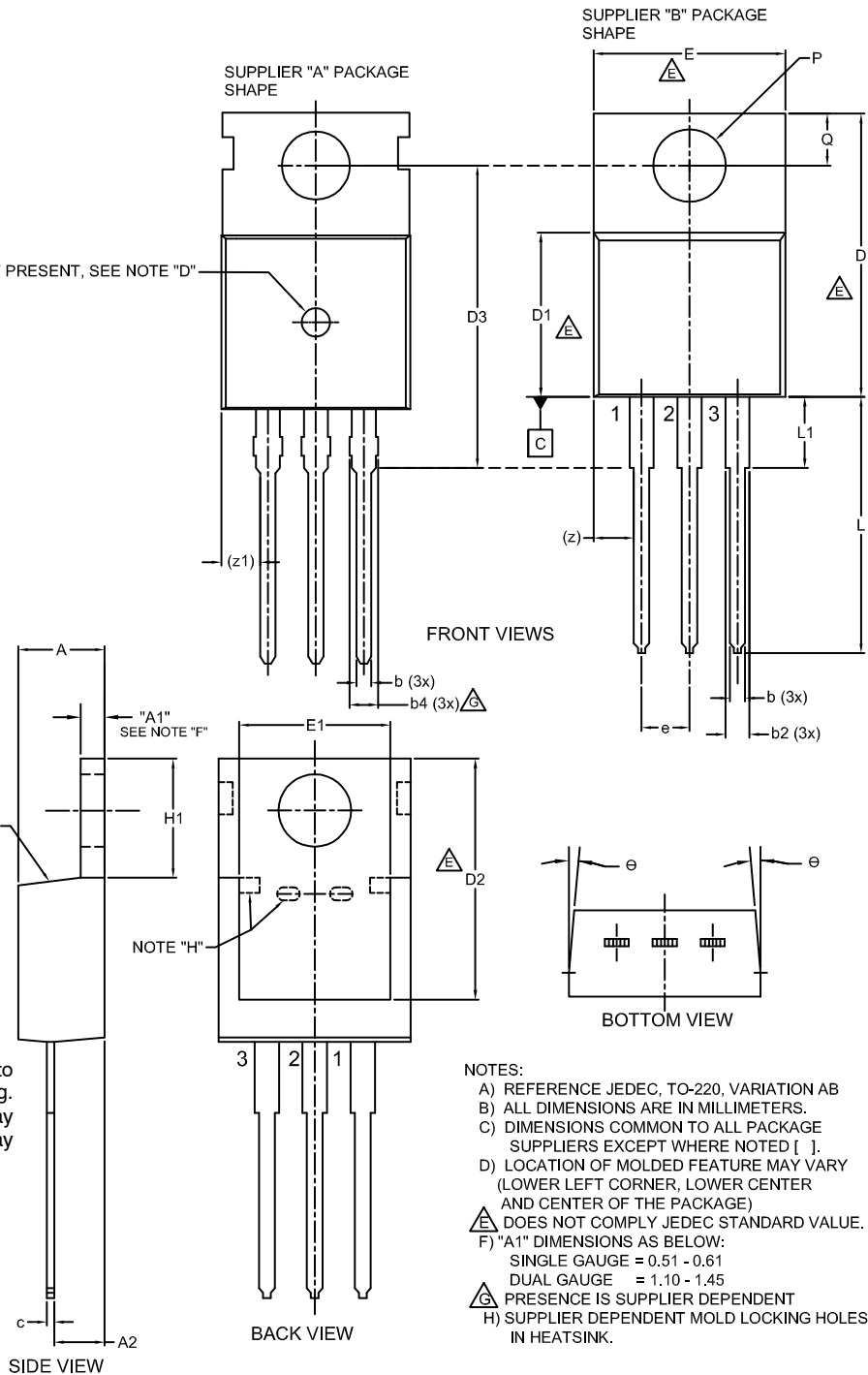
DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	4.00	--	4.70
A1	SEE NOTE "F"		
A2	2.10	--	2.85
b	0.55	--	1.00
b2	1.10	--	1.62
b4	1.42	--	1.62
c	0.36	--	0.60
D	13.90	--	16.30
D1	8.13	--	9.40
D2	11.50	--	14.30
D3	15.42	--	16.51
E	9.65	--	10.67
E1	7.59	--	8.65
e	2.40	--	2.67
H1	6.06	--	6.69
L	12.70	--	14.04
L1	2.70	--	4.10
P	3.50	--	4.00
Q	2.50	--	3.40
z	2.13 REF		
z1	2.06 REF		
θ	3°	--	5°

IF PRESENT, SEE NOTE "D"

**GENERIC**  
**MARKING DIAGRAM\***


XXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
ZZ = Assembly Lot Code

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.


**NOTES:**

- A) REFERENCE JEDEC, TO-220, VARIATION AB
- B) ALL DIMENSIONS ARE IN MILLIMETERS.
- C) DIMENSIONS COMMON TO ALL PACKAGE SUPPLIERS EXCEPT WHERE NOTED [ ].
- D) LOCATION OF MOLDED FEATURE MAY VARY (LOWER LEFT CORNER, LOWER CENTER AND CENTER OF THE PACKAGE)
- E) DOES NOT COMPLY JEDEC STANDARD VALUE.
- F) "A1" DIMENSIONS AS BELOW:  
SINGLE GAUGE = 0.51 - 0.61  
DUAL GAUGE = 1.10 - 1.45
- G) PRESENCE IS SUPPLIER DEPENDENT
- H) SUPPLIER DEPENDENT MOLD LOCKING HOLES IN HEATSINK.

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