

# MOSFET – N-Channel, SUPERFET®

**600 V, 11 A, 380 mΩ**

## FCP11N60, FCPF11N60

### Description

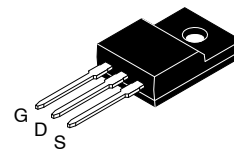
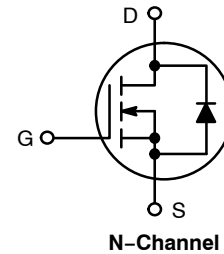
SUPERFET MOSFET is onsemi's first generation of high voltage super-junction (SJ) MOSFET family that is utilizing charge balance technology for outstanding low on-resistance and lower gate charge performance. This technology is tailored to minimize conduction loss, provide superior switching performance, 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

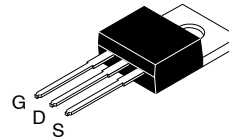
- 650 V @  $T_J = 150^\circ\text{C}$
- $R_{DS(on)} = 320\text{ m}\Omega$  (Typ.)
- Ultra Low Gate Charge (Typ.  $Q_g = 40\text{ nC}$ )
- Low Effective Output Capacitance (Typ.  $C_{oss(eff.)} = 95\text{ pF}$ )
- 100% Avalanche Tested
- These Devices are Pb-Free and are RoHS Compliant

$V_{DS}$	$R_{DS(on)}\text{ MAX}$	$I_D\text{ MAX}$
600 V	380 mΩ @ 10 V	11 A*

\*Drain current limited by maximum junction temperature.

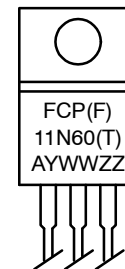


TO-220 Fullpack, 3-Lead  
 / TO-220F-3SG  
 CASE 221AT



TO-220-3LD  
 CASE 340AT

### MARKING DIAGRAM



FCP(F)11N60(T) = Specific Device Code  
 A = Assembly Location  
 YWW = Date Code (Year & Week)  
 ZZ = Assembly Lot

### ORDERING INFORMATION

Device	Package	Shipping
FCP11N60	TO-220-3	1000 Units / Tube
FCPF11N60	TO-220-3 FullPak	1000 Units / Tube
FCPF11N60T		

# FCP11N60, FCPF11N60

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

Symbol	Parameter		FCP11N60	FCPF11N60	Unit
$V_{DSS}$	Drain-Source Voltage		600		V
$I_D$	Drain Current	- Continuous ( $T_C = 25^\circ\text{C}$ )	11	11*	A
		- Continuous ( $T_C = 100^\circ\text{C}$ )	7	7*	
$I_{DM}$	Drain Current	- Pulsed (Note 1)	33	33*	A
$V_{GSS}$	Gate-Source Voltage		$\pm 30$		V
$E_{AS}$	Single Pulsed Avalanche Energy (Note 2)		340		mJ
$I_{AR}$	Avalanche Current (Note 1)		11		A
$E_{AR}$	Repetitive Avalanche Energy (Note 1)		12.5		mJ
dv/dt	Peak Diode Recovery dv/dt (Note 3)		4.5		V/ns
$P_D$	Power Dissipation	( $T_C = 25^\circ\text{C}$ )	125	36	W
		- Derate Above $25^\circ\text{C}$	1.0	0.29	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 Purposes, 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.  $I_{AS} = 5.5\text{ A}$ ,  $V_{DD} = 50\text{ V}$ ,  $R_G = 25\ \Omega$ , starting  $T_J = 25^\circ\text{C}$ .
3.  $I_{SD} \leq 11\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq BV_{DSS}$ , starting  $T_J = 25^\circ\text{C}$ .

## THERMAL CHARACTERISTICS

Symbol	Parameter	FCP11N60	FCPF11N60	Unit
$R_{\theta JC}$	Thermal Resistance, Junction-to-Case	1.0	3.5	$^\circ\text{C}/\text{W}$
$R_{\theta CS}$	Thermal Resistance, Case-to-Sink	0.5	-	$^\circ\text{C}/\text{W}$
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient	62.5	62.5	$^\circ\text{C}/\text{W}$

# FCP11N60, FCPF11N60

## ELECTRICAL CHARACTERISTICS (T<sub>C</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-Source Breakdown Voltage	V <sub>GS</sub> = 0 V, I <sub>D</sub> = 250 μA, T <sub>J</sub> = 25°C	600	-	-	V
		V <sub>GS</sub> = 0 V, I <sub>D</sub> = 250 μA, 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> = 11 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>GSSF</sub>	Gate-Body Leakage Current, Forward	V <sub>GS</sub> = 30 V, V <sub>DS</sub> = 0 V	-	-	100	nA
I <sub>GSSR</sub>	Gate-Body Leakage Current, Reverse	V <sub>GS</sub> = -30 V, V <sub>DS</sub> = 0 V	-	-	-100	nA

### ON CHARACTERISTICS

V <sub>GS(th)</sub>	Gate Threshold Voltage	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA	3.0	-	5.0	V
R <sub>DS(on)</sub>	Static Drain-Source On-Resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 5.5 A	-	0.32	0.38	Ω
g <sub>FS</sub>	Forward Transconductance	V <sub>DS</sub> = 40 V, I <sub>D</sub> = 5.5 A (Note 4)	-	9.7	-	S

### DYNAMIC CHARACTERISTICS

C <sub>iss</sub>	Input Capacitance	V <sub>DS</sub> = 25 V, V <sub>GS</sub> = 0 V, f = 1 MHz	-	1148	1490	pF
C <sub>oss</sub>	Output Capacitance		-	671	870	pF
C <sub>rss</sub>	Reverse Transfer Capacitance		-	63	82	pF
C <sub>oss</sub>	Output Capacitance	V <sub>DS</sub> = 480 V, V <sub>GS</sub> = 0 V, f = 1 MHz	-	35	-	pF
C <sub>oss(eff.)</sub>	Effective Output Capacitance	V <sub>DS</sub> = 0 V to 400 V, V <sub>GS</sub> = 0 V	-	95	-	pF

### SWITCHING CHARACTERISTICS

t <sub>d(on)</sub>	Turn-On Delay Time	V <sub>DD</sub> = 300 V, I <sub>D</sub> = 11 A, R <sub>G</sub> = 25 Ω (Note 4, 5)	-	34	80	ns
t <sub>r</sub>	Turn-On Rise Time		-	98	205	ns
t <sub>d(off)</sub>	Turn-Off Delay Time		-	119	250	ns
t <sub>f</sub>	Turn-Off Fall Time		-	56	120	ns
Q <sub>g</sub>	Total Gate Charge	V <sub>DS</sub> = 480 V, I <sub>D</sub> = 11 A, V <sub>GS</sub> = 10 V (Note 4, 5)	-	40	52	nC
Q <sub>gs</sub>	Gate-Source Charge		-	7.2	-	nC
Q <sub>gd</sub>	Gate-Drain Charge		-	21	-	nC

### DRAIN-SOURCE DIODE CHARACTERISTICS AND MAXIMUM RATINGS

I <sub>S</sub>	Maximum Continuous Drain-Source Diode Forward Current	-	-	11	A	
I <sub>SM</sub>	Maximum Pulsed Drain-Source Diode Forward Current	-	-	33	A	
V <sub>SD</sub>	Drain-Source Diode Forward Voltage	V <sub>GS</sub> = 0 V, I <sub>S</sub> = 11 A	-	-	1.4	V
t <sub>rr</sub>	Reverse Recovery Time	V <sub>GS</sub> = 0 V, I <sub>S</sub> = 11 A, dI <sub>F</sub> /dt = 100 A/μs (Note 4)	-	390	-	ns
Q <sub>rr</sub>	Reverse Recovery Charge		-	5.7	-	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. Pulse Test : Pulse width ≤ 300 μs, Duty cycle ≤ 2%

5. Essentially independent of operating temperature

# FCP11N60, FCPF11N60

## TYPICAL PERFORMANCE CHARACTERISTICS

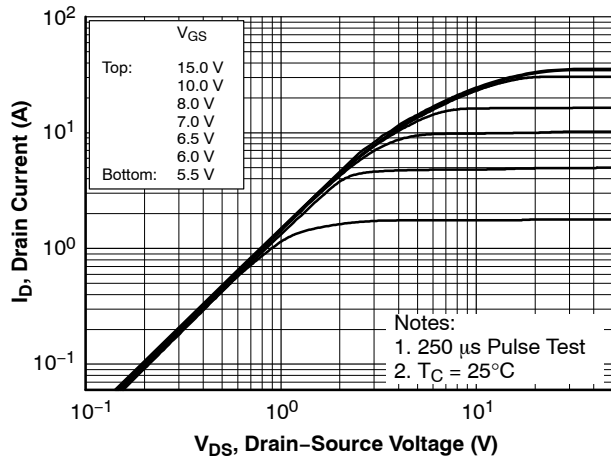


Figure 1. On-Region Characteristics

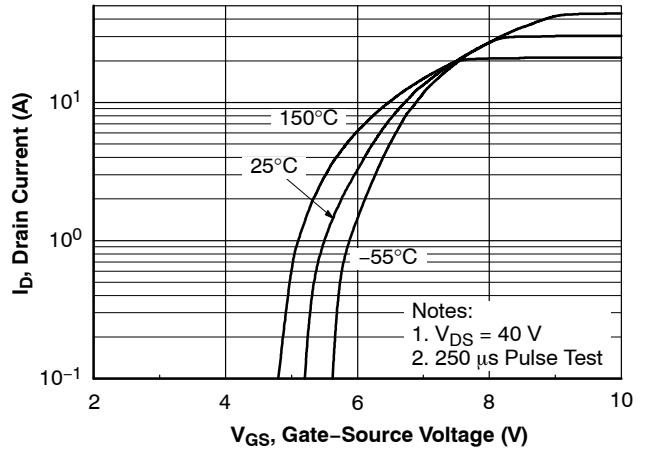


Figure 2. Transfer Characteristics

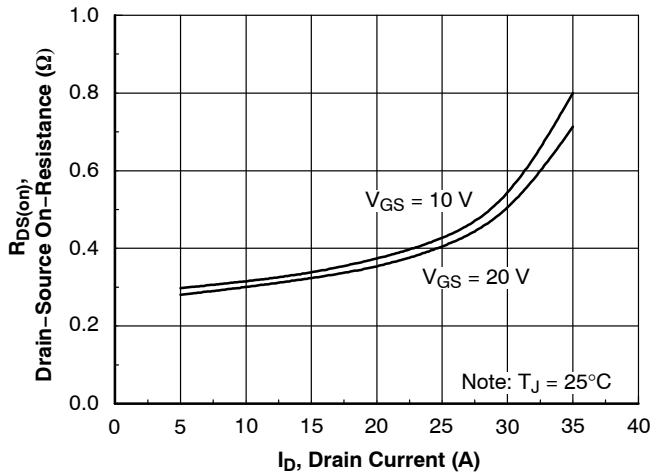


Figure 3. On-Resistance Variation vs. Drain Current and Gate Voltage

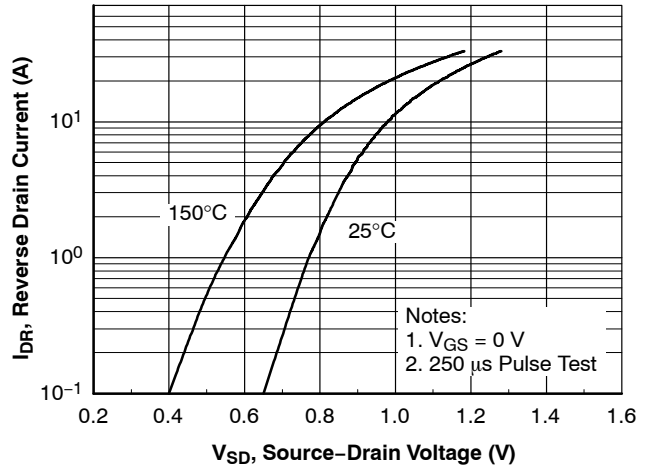


Figure 4. Body Diode Forward Voltage Variation vs. Source Current and Temperature

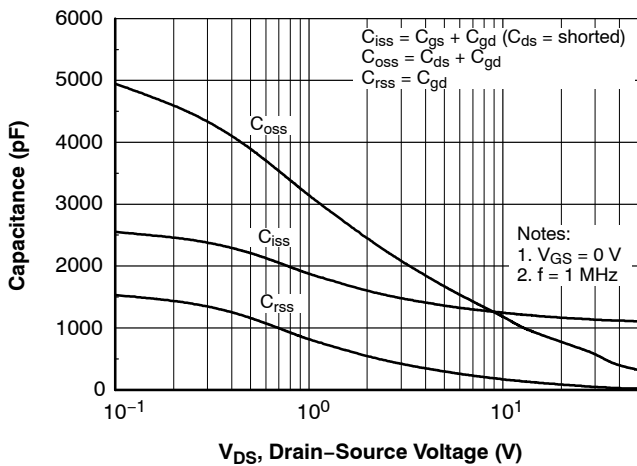


Figure 5. Capacitance Characteristics

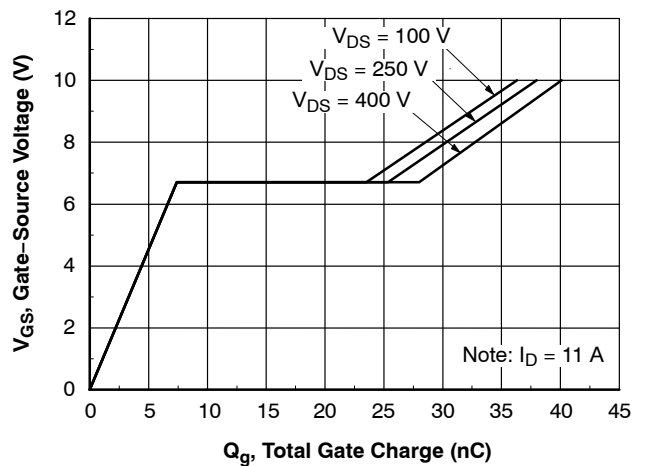


Figure 6. Gate Charge Characteristics

# FCP11N60, FCPF11N60

## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

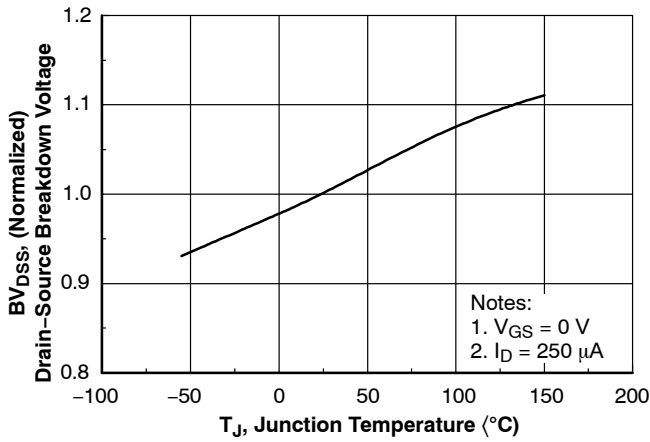


Figure 7. Breakdown Voltage Variation vs. Temperature

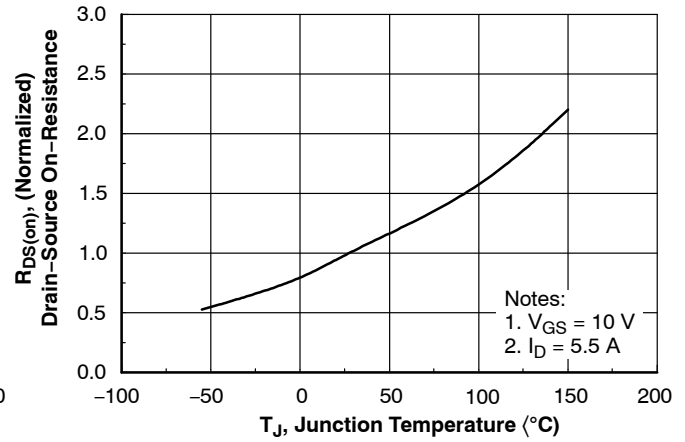


Figure 8. On-Resistance Variation vs. Temperature

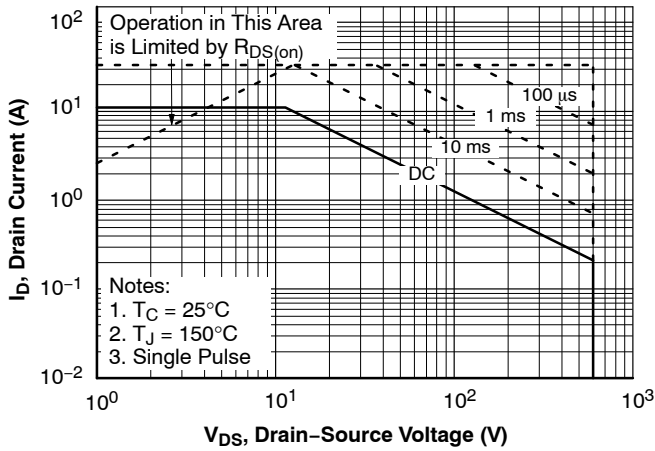


Figure 9. Maximum Safe Operating Area for FCP11N60

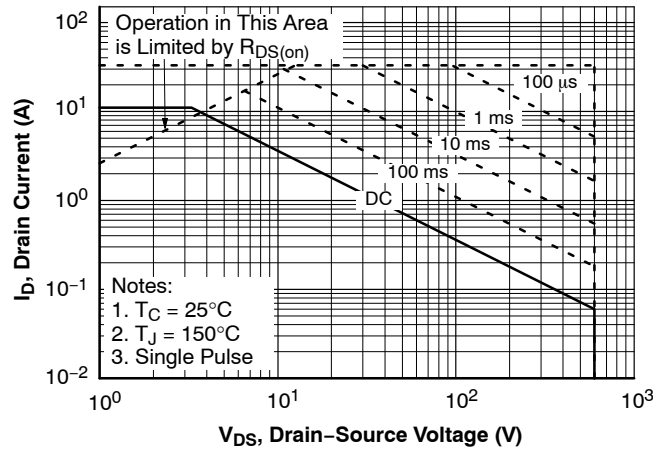


Figure 10. Maximum Safe Operating Area for FCPF11N60

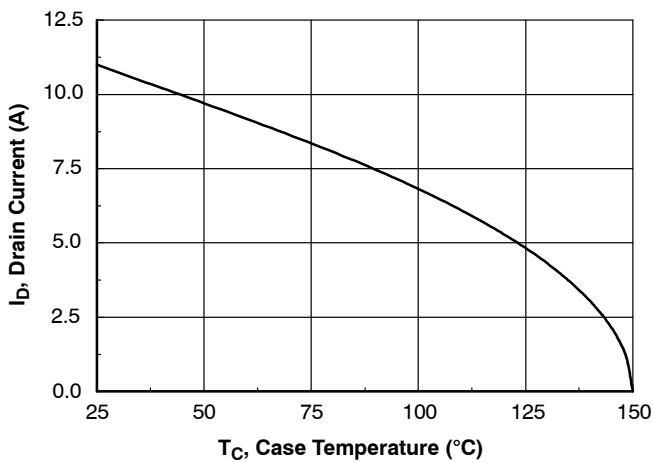


Figure 11. Maximum Drain Current vs. Case Temperature

# FCP11N60, FCPF11N60

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

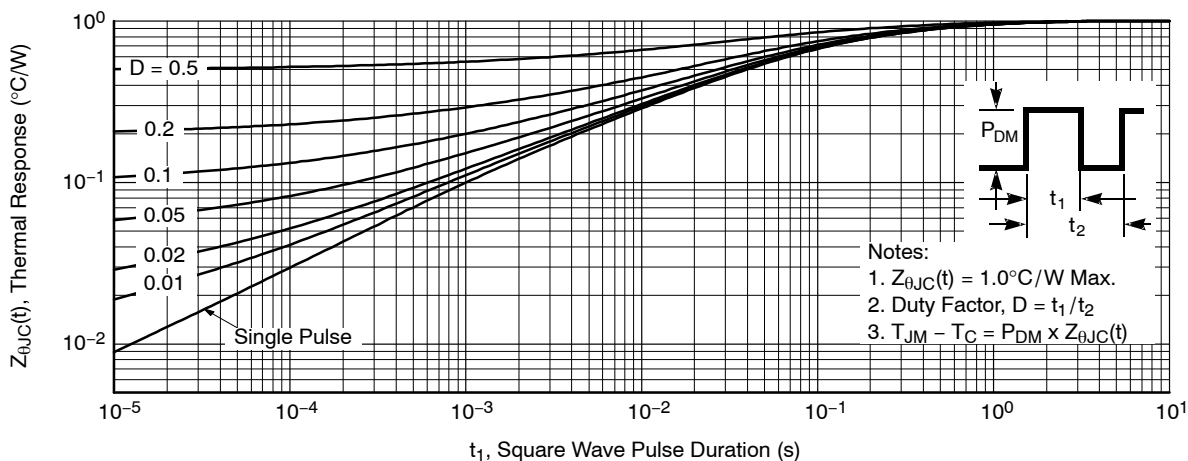


Figure 12. Transient Thermal Response Curve for FCP11N60

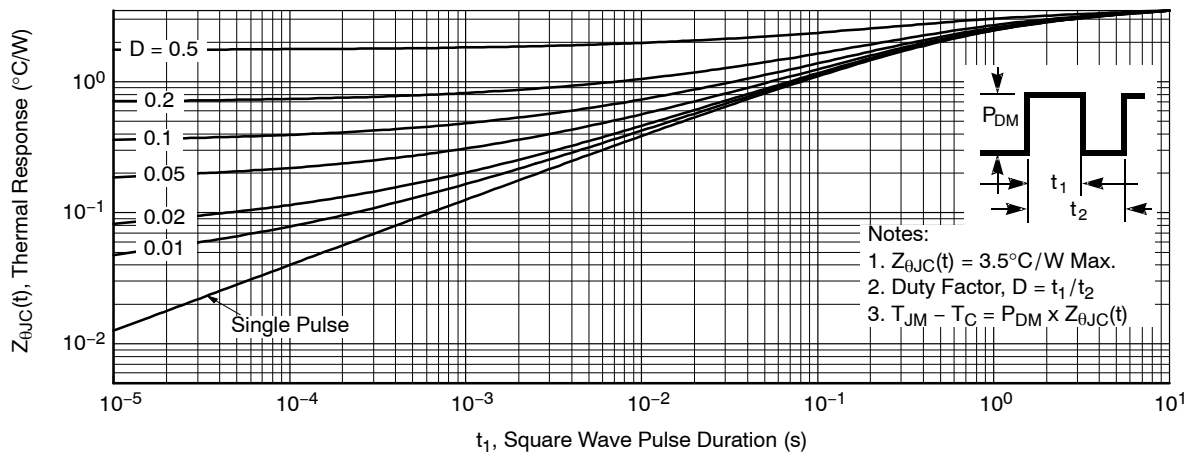


Figure 13. Transient Thermal Response Curve for FCPF11N60

## FCP11N60, FCPF11N60

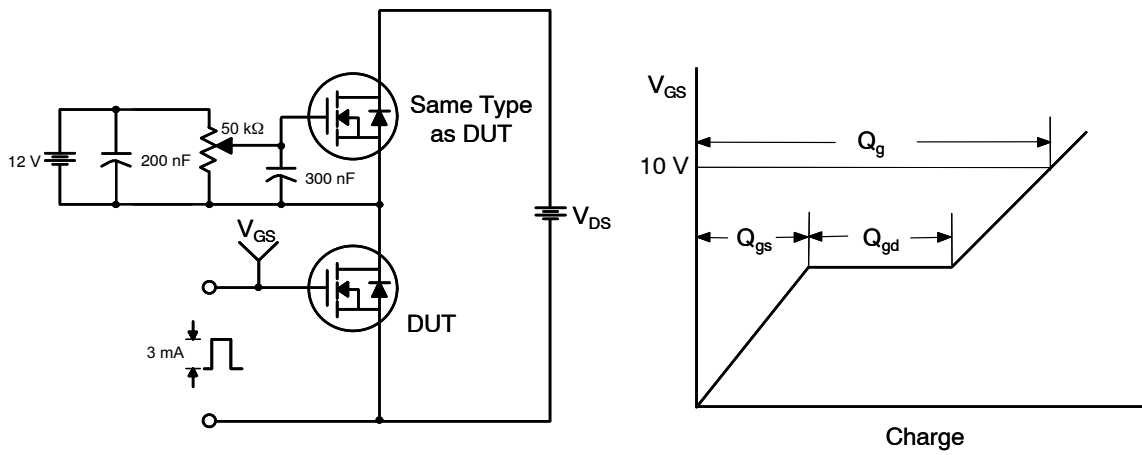


Figure 14. Gate Charge Test Circuit & Waveform

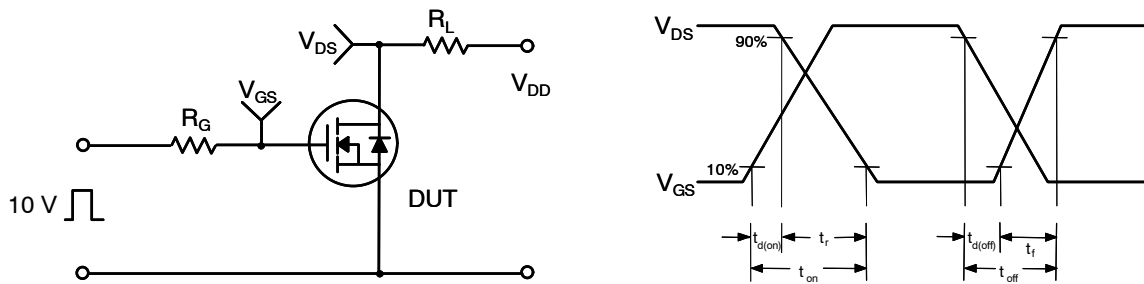


Figure 15. Resistive Switching Test Circuit & Waveforms

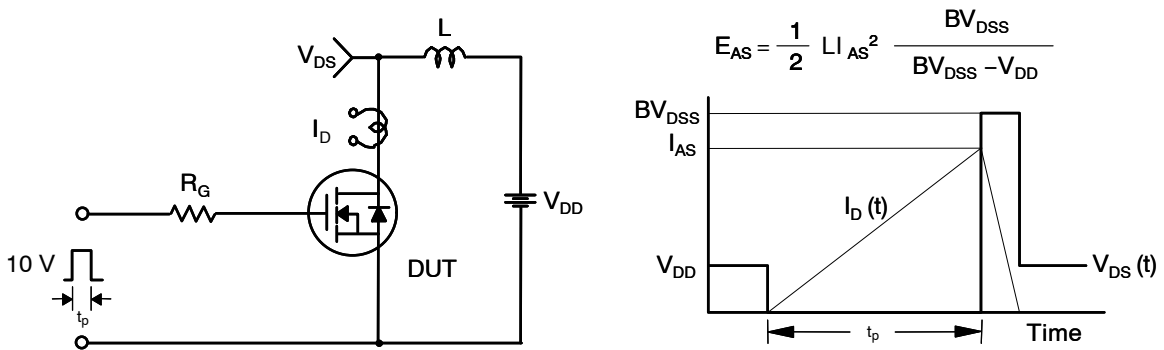


Figure 16. Unclamped Inductive Switching Test Circuit & Waveforms

# FCP11N60, FCPF11N60

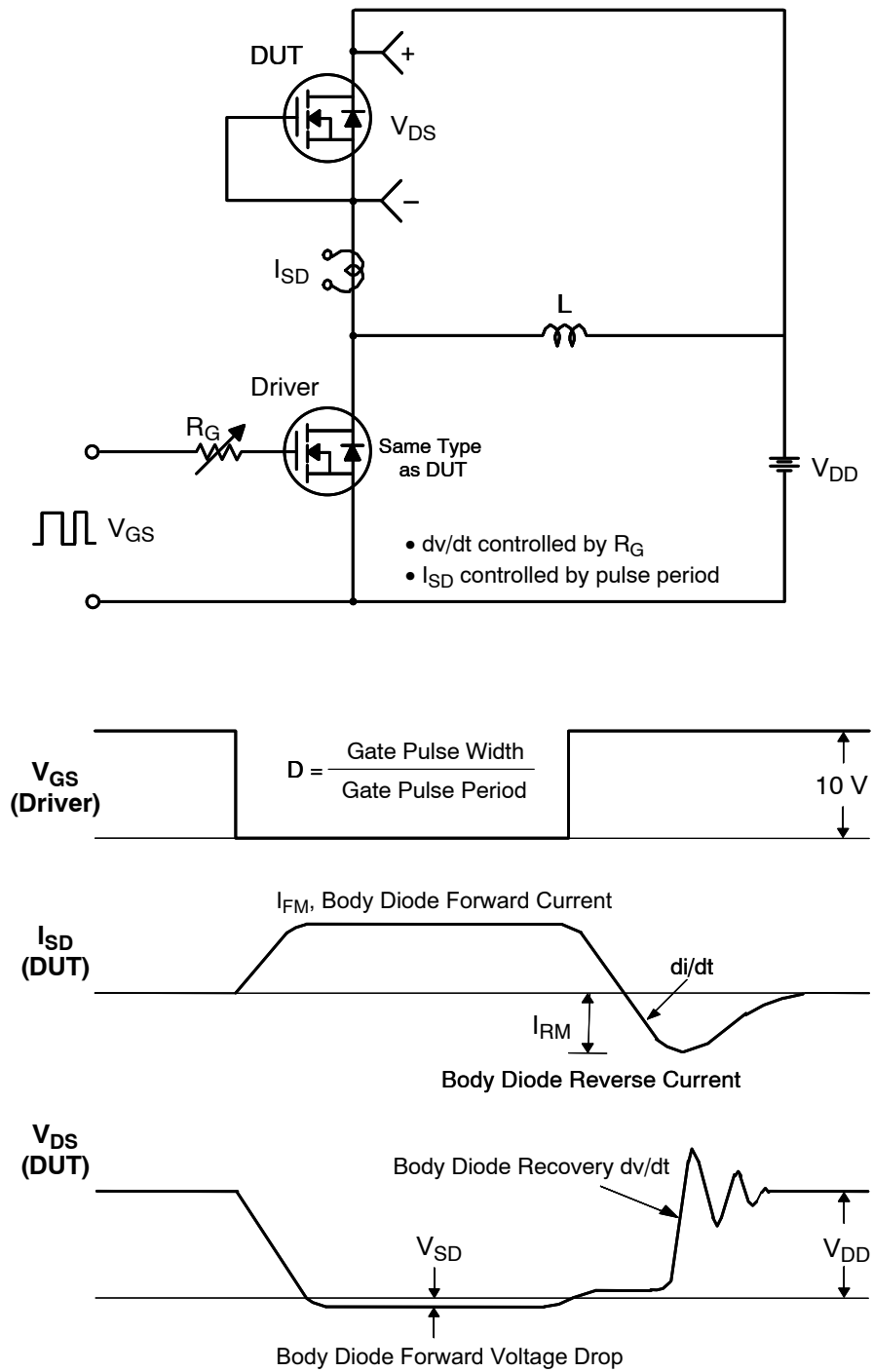
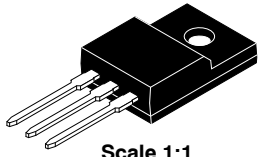


Figure 17. Peak Diode Recovery  $dv/dt$  Test Circuit & Waveforms

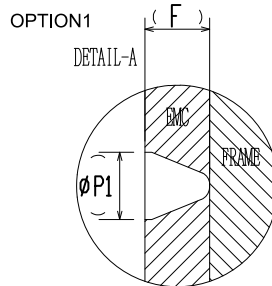
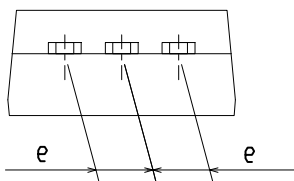


**TO-220 Fullpack, 3-Lead / TO-220F-3SG**  
**CASE 221AT**  
**ISSUE B**

DATE 19 JAN 2021



Scale 1:1



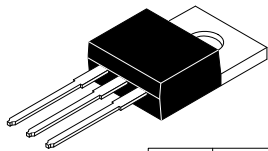
DIM	MILLIMETERS		
	MIN	NOM	MAX
A	4.50	4.70	4.90
A1	2.56	2.76	2.96
A2	2.34	2.54	2.74
b	0.70	0.80	0.90
b2	~	~	1.47
c	0.45	0.50	0.60
D	15.67	15.87	16.07
D1	15.60	15.80	16.00
E	9.96	10.16	10.36
e	2.34	2.54	2.74
F	~	0.84	~
H1	6.48	6.68	6.88
L	12.78	12.98	13.18
L1	3.03	3.23	3.43
∅ P	2.98	3.18	3.38
∅ P1	~	1.00	~
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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<b>DESCRIPTION:</b>	<b>TO-220 FULLPACK, 3-LEAD / TO-220F-3SG</b>	<b>PAGE 1 OF 1</b>

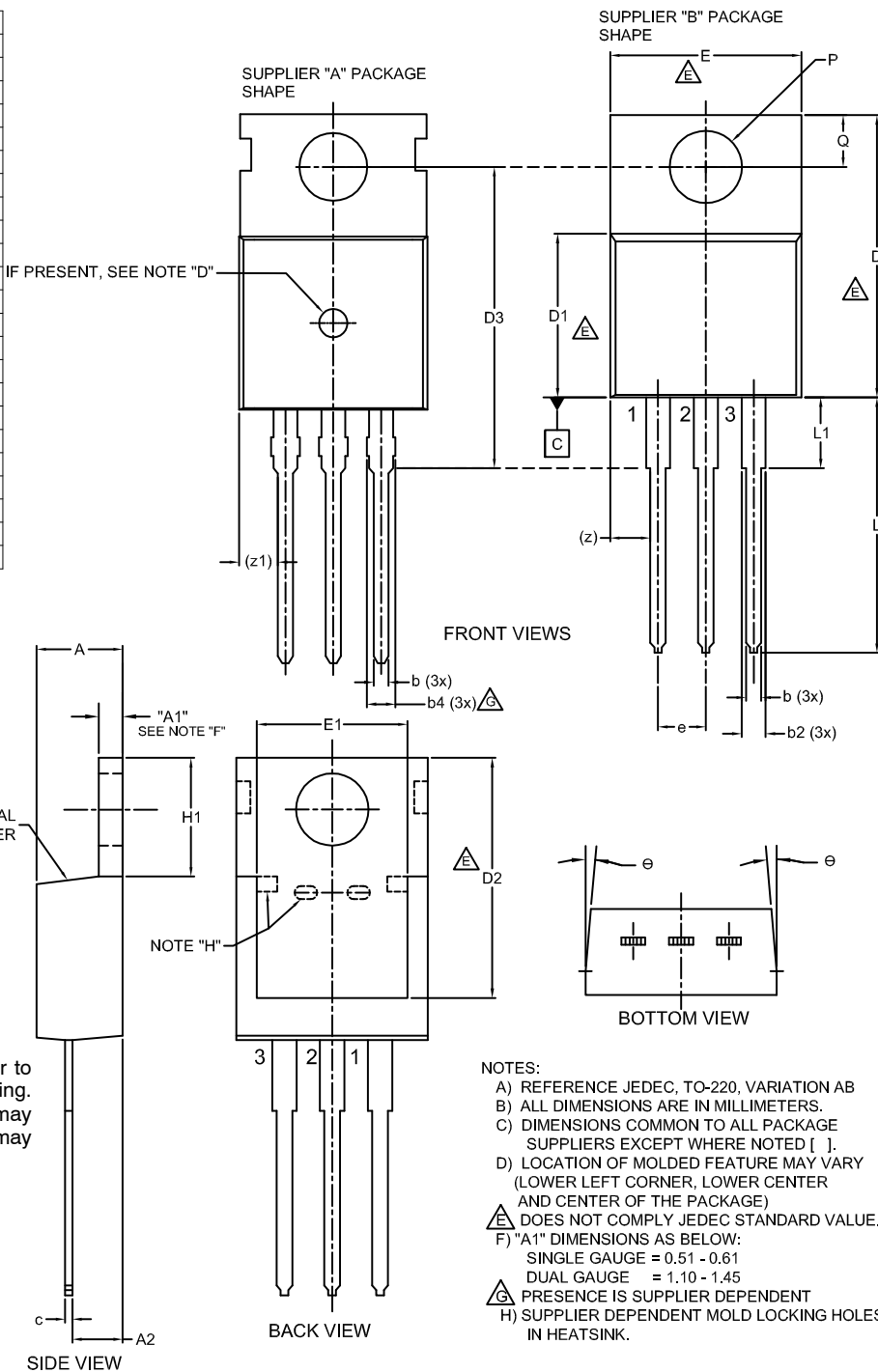
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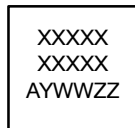
TO-220-3LD  
CASE 340AT  
ISSUE B

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°



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)
  - ⚠ DOES NOT COMPLY JEDEC STANDARD VALUE.
  - F) "A1" DIMENSIONS AS BELOW:  
SINGLE GAUGE = 0.51 - 0.61  
DUAL GAUGE = 1.10 - 1.45
  - ⚠ PRESENCE IS SUPPLIER DEPENDENT
  - H) SUPPLIER DEPENDENT MOLD LOCKING HOLES IN HEATSINK.

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