

# MOSFET – N-Channel, SUPERFET®

**600 V, 11 A, 380 mΩ**

**FCP11N60, FCPF11N60**

## Description

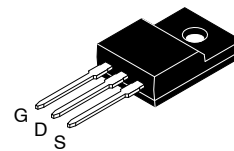
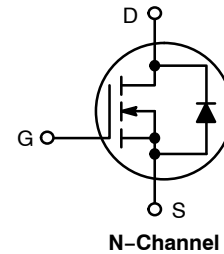
SUPERFET MOSFET is onsemi's first generation of high voltage super-junction (SJ) MOSFET family that is utilizing charge balance technology for outstanding low on-resistance and lower gate charge performance. This technology is tailored to minimize conduction loss, provide superior switching performance,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

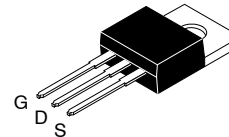
- 650 V @  $T_J = 150^{\circ}\text{C}$
- $R_{DS(on)} = 320\text{ m}\Omega$  (Typ.)
- Ultra Low Gate Charge (Typ.  $Q_g = 40\text{ nC}$ )
- Low Effective Output Capacitance (Typ.  $C_{oss(eff.)} = 95\text{ pF}$ )
- 100% Avalanche Tested
- These Devices are Pb-Free and are RoHS Compliant

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

\*Drain current limited by maximum junction temperature.

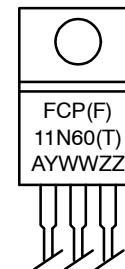


TO-220 Fullpack, 3-Lead  
/ TO-220F-3SG  
CASE 221AT



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 | 1000 Units / Tube |
| FCPF11N60T | FullPak  |                   |

# 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 |
|--------------------------------------|---|--|-----|-----|------|------|
| <b>OFF CHARACTERISTICS</b>           |   |  |     |     |      |      |
| 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

## TYPICAL PERFORMANCE CHARACTERISTICS

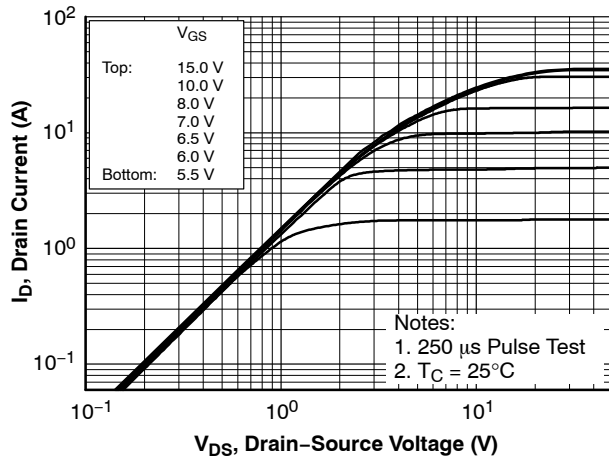


Figure 1. On-Region Characteristics

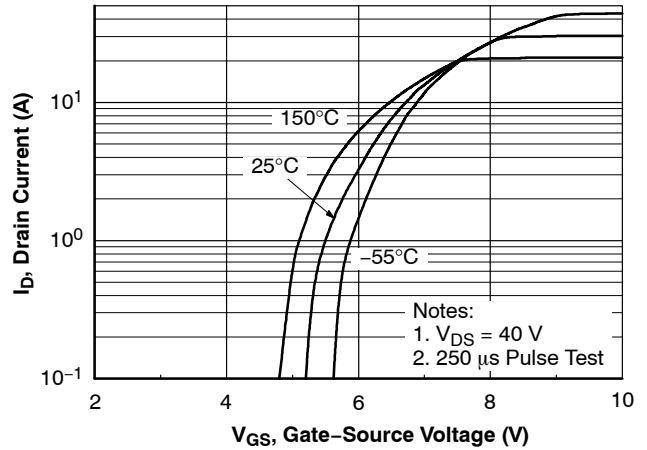


Figure 2. Transfer Characteristics

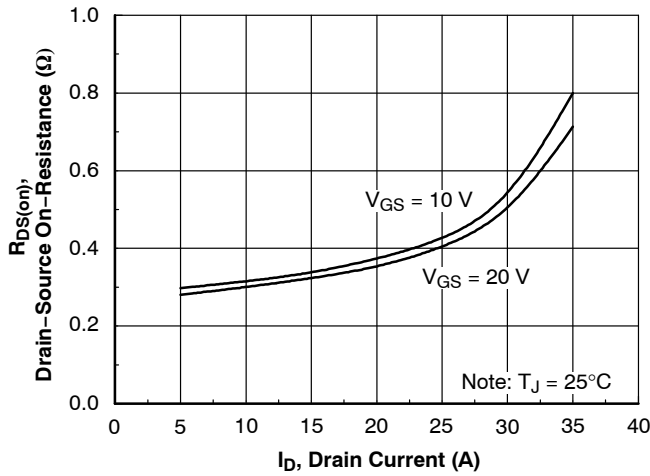


Figure 3. On-Resistance Variation vs. Drain Current and Gate Voltage

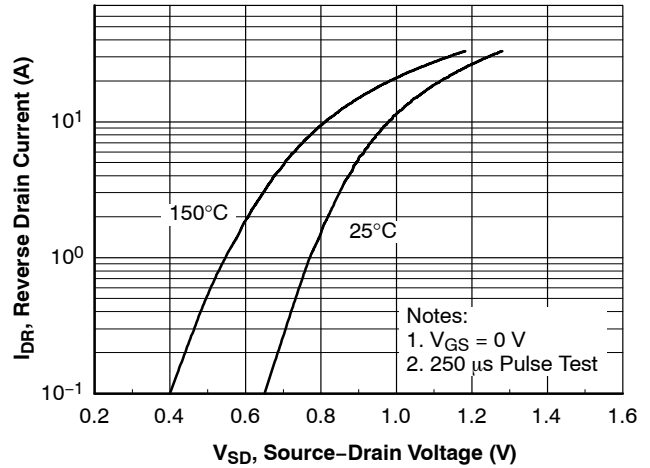


Figure 4. Body Diode Forward Voltage Variation vs. Source Current and Temperature

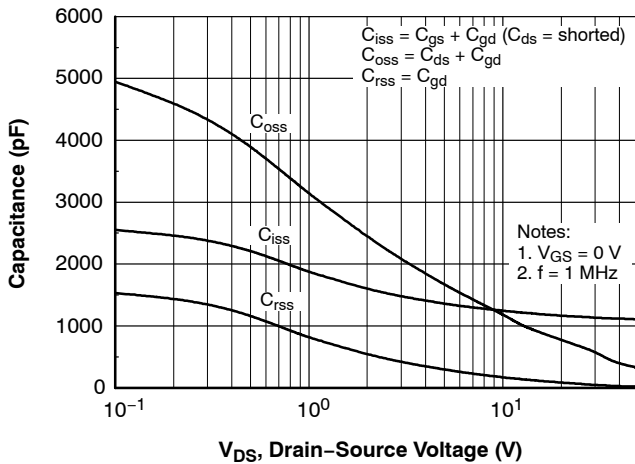


Figure 5. Capacitance Characteristics

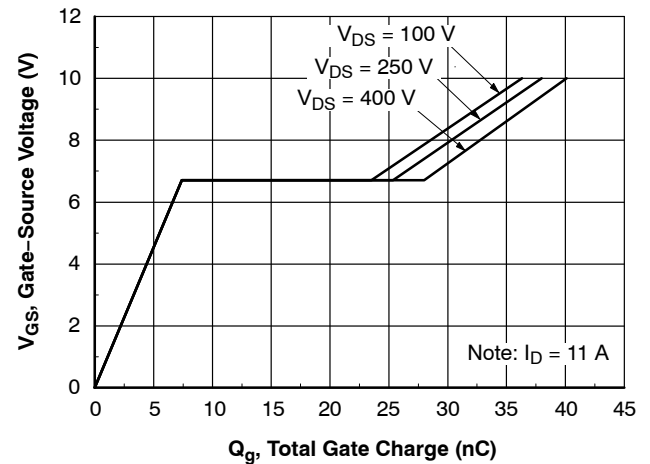


Figure 6. Gate Charge Characteristics

# FCP11N60, FCPF11N60

## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

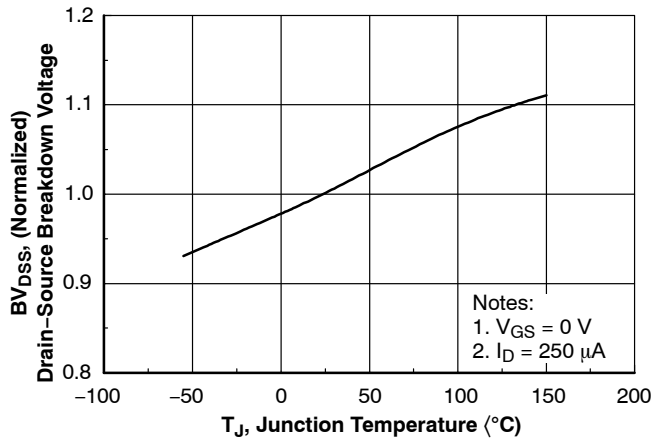


Figure 7. Breakdown Voltage Variation vs. Temperature

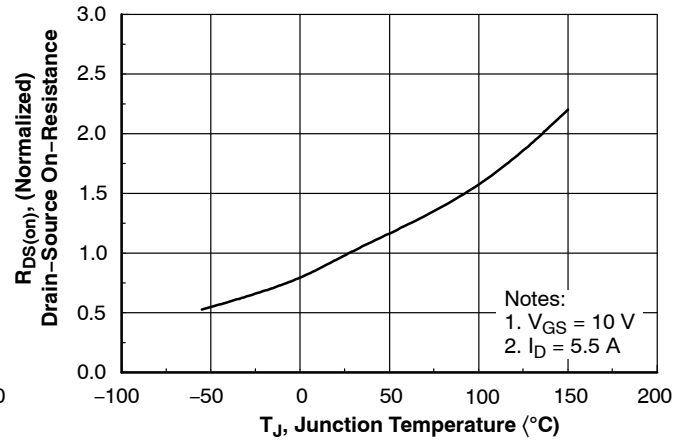


Figure 8. On-Resistance Variation vs. Temperature

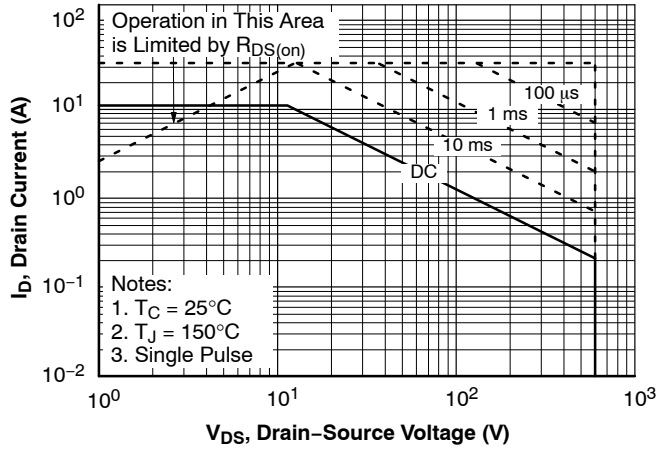


Figure 9. Maximum Safe Operating Area for FCP11N60

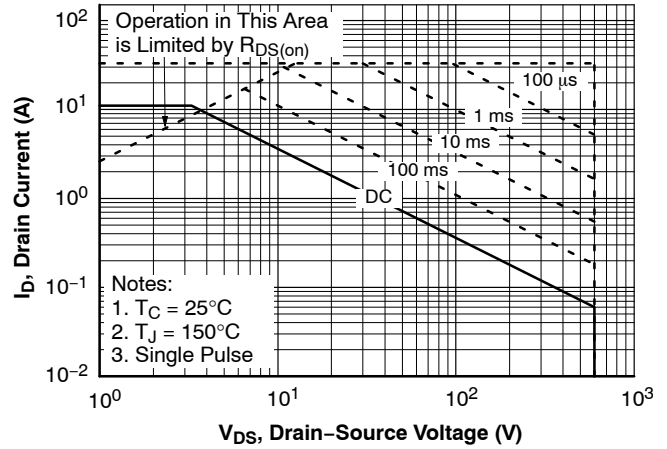


Figure 10. Maximum Safe Operating Area for FCPF11N60

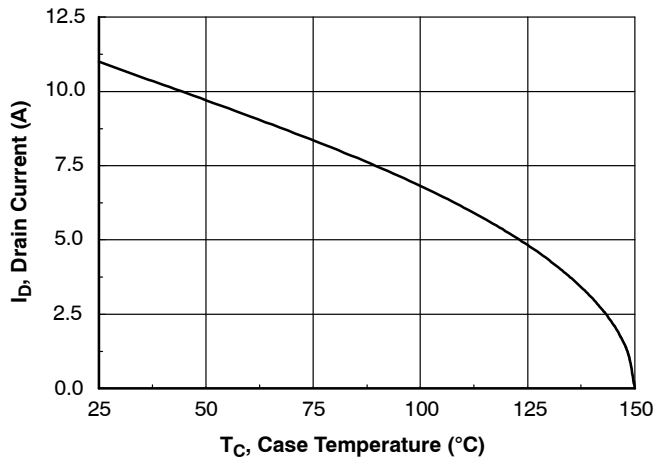


Figure 11. Maximum Drain Current vs. Case Temperature

# FCP11N60, FCPF11N60

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

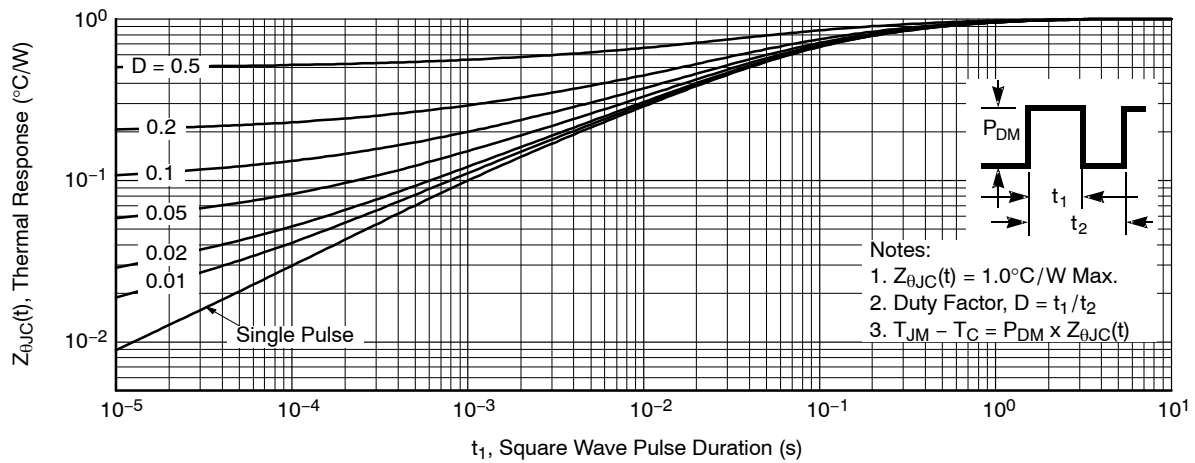


Figure 12. Transient Thermal Response Curve for FCP11N60

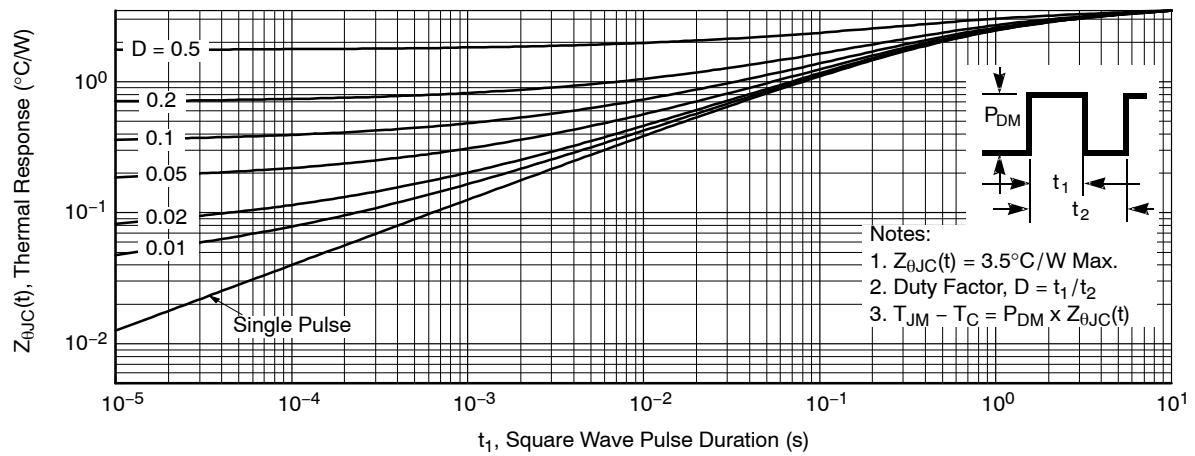
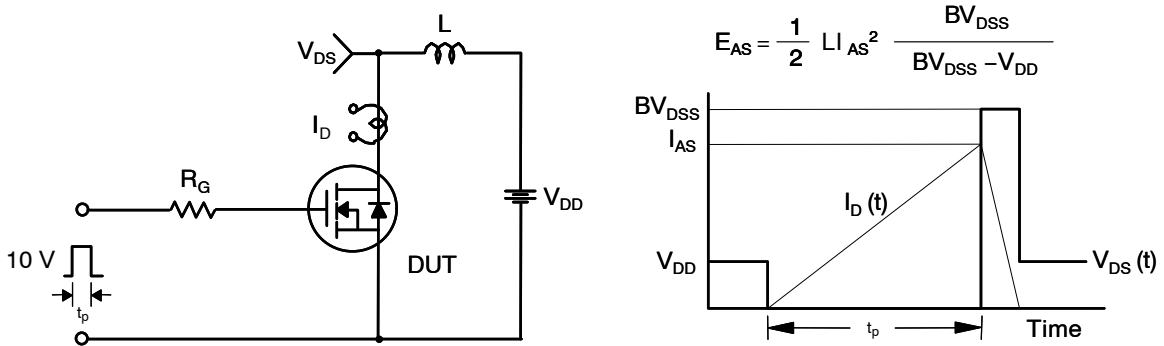
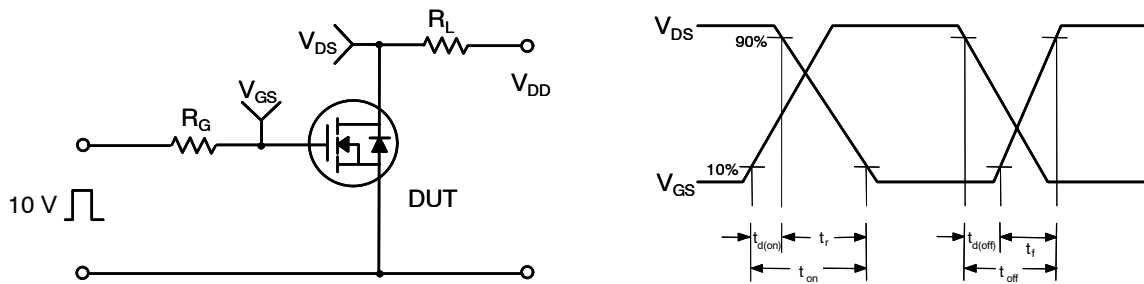
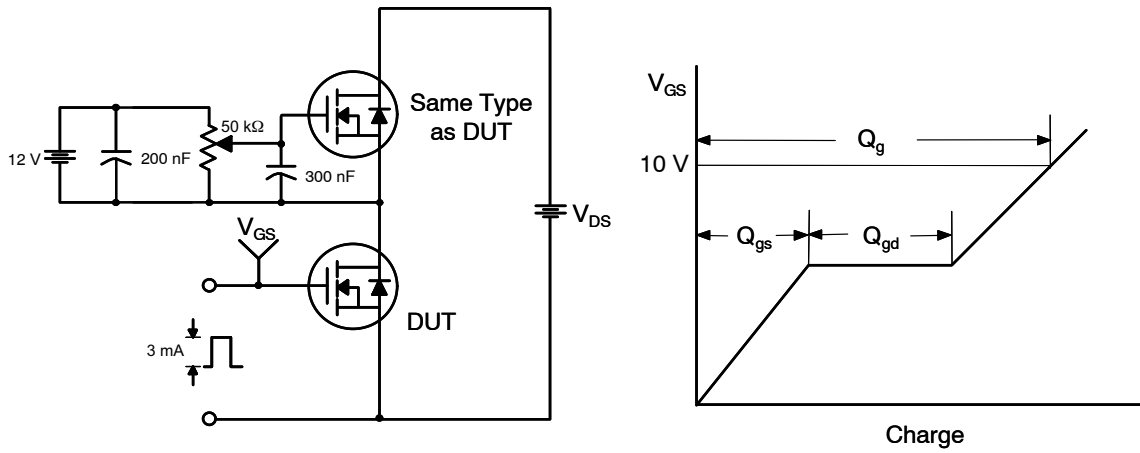
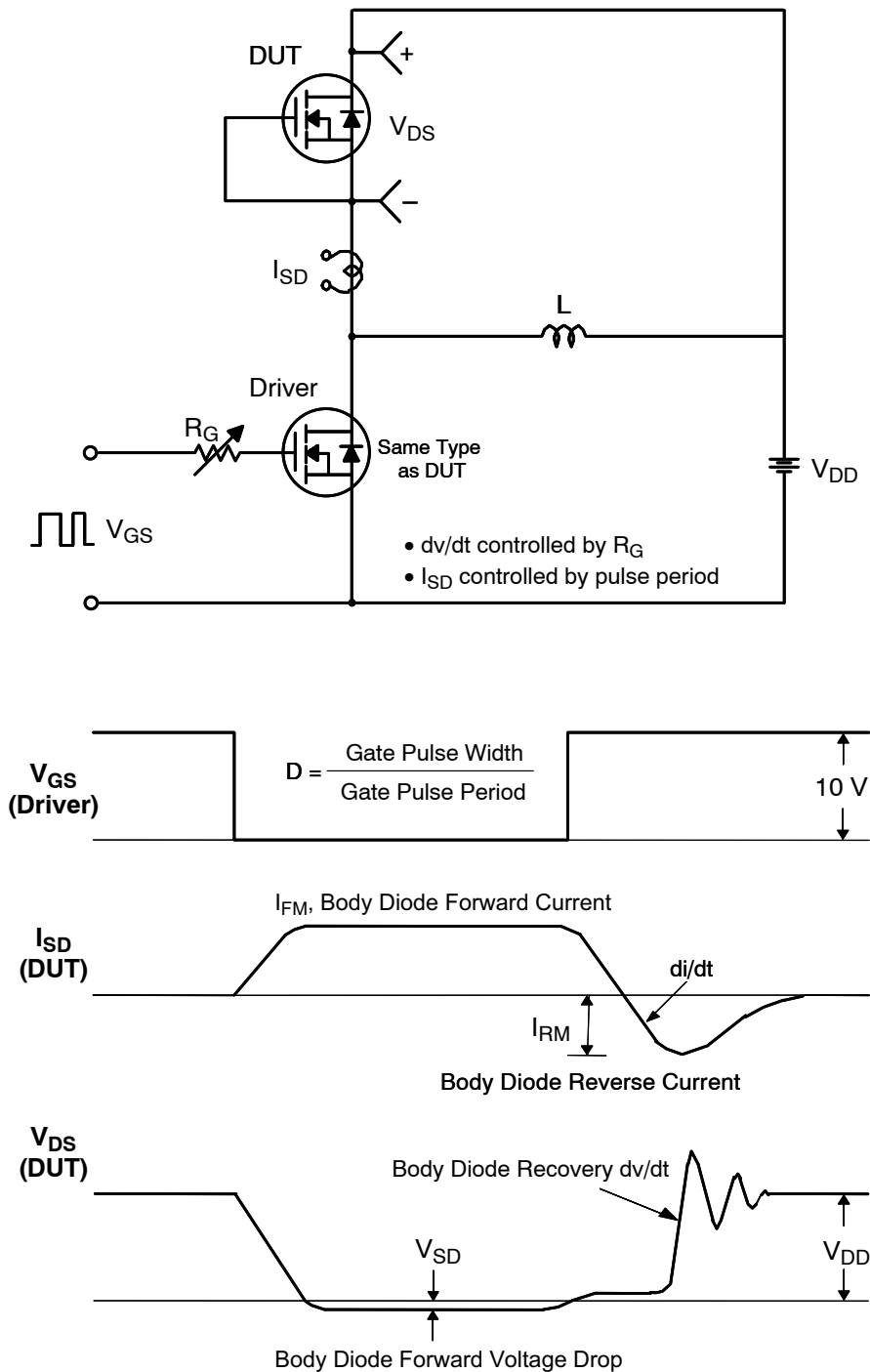


Figure 13. Transient Thermal Response Curve for FCPF11N60

## FCP11N60, FCPF11N60



## FCP11N60, FCPF11N60



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

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# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS

ON Semiconductor®

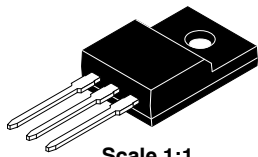
ON

### TO-220 Fullpack, 3-Lead / TO-220F-3SG

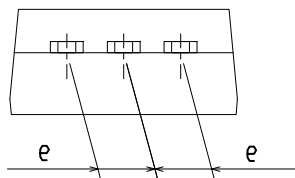
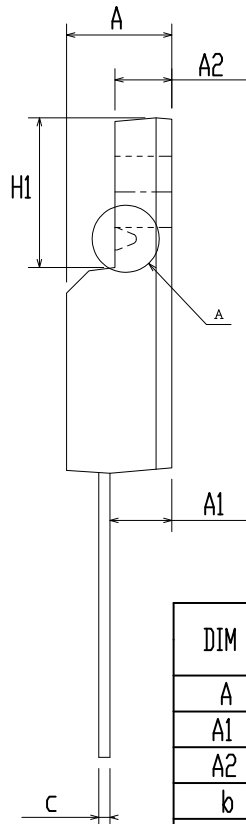
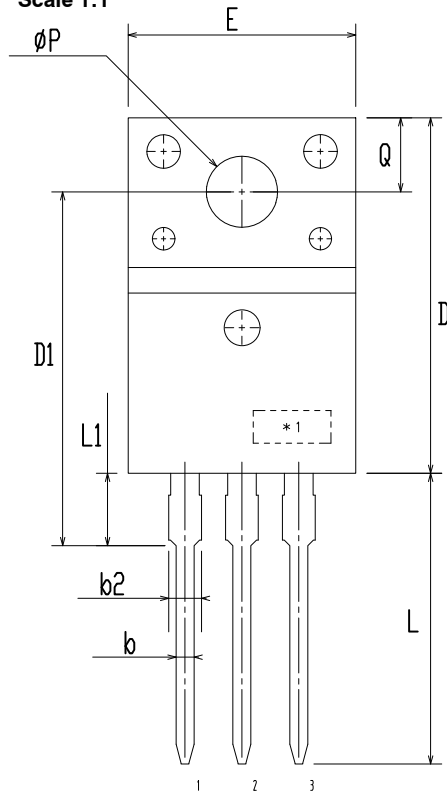
#### CASE 221AT

#### ISSUE B

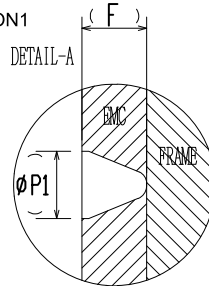
DATE 19 JAN 2021



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

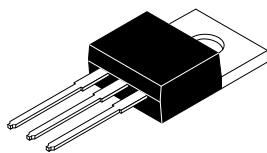
OPTION 2 - NO SUPPORT PIN HOLE

|                         |  |   |
|-------------------------|--|---|
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| <b>DESCRIPTION:</b>     | <b>TO-220 FULLPACK, 3-LEAD / TO-220F-3SG</b> | <b>PAGE 1 OF 1</b>  |

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# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

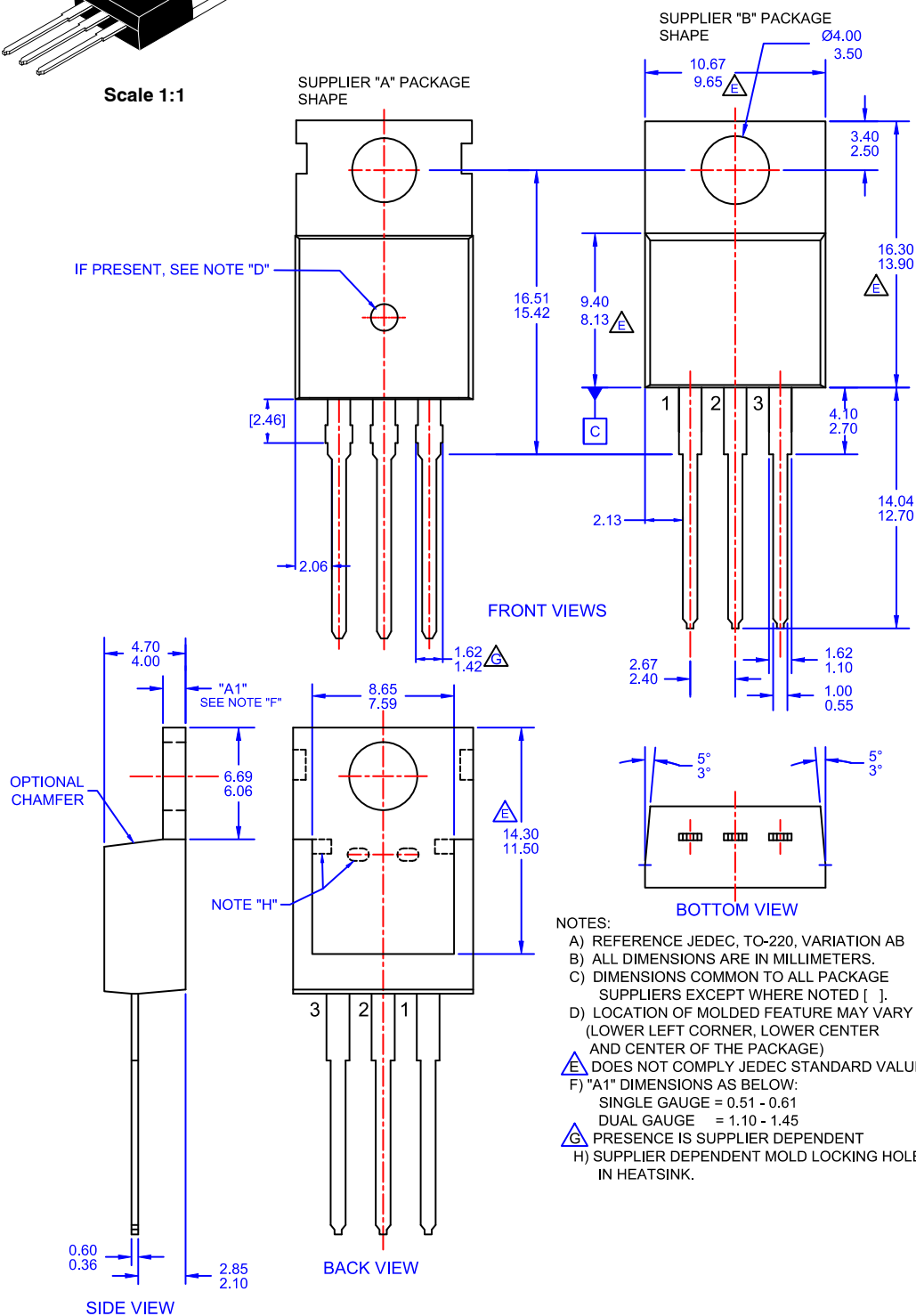
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Scale 1:1

## TO-220-3LD CASE 340AT ISSUE A

DATE 03 OCT 2017



### 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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